



**Guam Waterworks Authority  
Master Planning Technical Assessment**

**January 29, 2010**

**Submitted to:**

United States Environmental Protection Agency  
Region 9  
Water Division  
75 Hawthorne Street  
San Francisco, CA 94105

**Submitted by:**

PG Environmental, LLC  
570 Herndon Parkway  
Suite 500  
Herndon, VA 20170

EPA Contract No.: EP-R9-08-01  
Task Order: 0016, Task 4

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# **Guam Waterworks Authority Master Planning Technical Assessment**

## **Executive Summary**

PG Environmental, LLC, (PG), under contract to U.S. EPA Region 9, Water Division, was tasked to conduct an assessment of the Guam Waterworks Authority's (GWA's) master plan activities, including the management of the planning programs, the 2010–2014 Capital Improvement Project (CIP) plan, and the recently submitted “Guam Waterworks Authority, Needs Assessment for Anticipated Guam Military Build-Up” (September 1, 2009) (Needs Assessment). The findings in this assessment report are based on PG's review of key, contemporary planning documents and intensive meetings with GWA staff and officials during the week of November 9, 2009. PG would like to thank GWA for its cooperation and assistance during this task.

GWA has had a history of non-compliance with federal and territorial water statutes. The water distribution system often exceeded the Maximum Contaminant Levels for microbial contaminants, and “boil notices” were common. The wastewater treatment plants, including the Northern District Wastewater Treatment Plant (NDWWTP), the Agana WWTP (a.k.a. Hagatna WWTP), and others, remain in continual violation of their National Pollutant Discharge Elimination System (NPDES) permit limits. In response to these violations, the Department of Justice filed suit against GWA in December 2002. In June 2003, the Court entered a Stipulated Order for Preliminary Relief for Civil Case No. 02-0035. Among other things, the Stipulated Order required GWA to hire qualified technical staff in key positions, including the General Manager, Chief Engineer, and Chief Financial Officer. These positions were filled, in accordance with the Stipulated Order requirements.

Some improvements have been achieved since the Stipulated Order was entered. Most notably, the quality of the drinking water supply has improved: The potable water supply now regularly meets primary drinking water standards, and boil notices are infrequent. In addition, GWA's General Manager, Chief Engineer, Chief Financial Officer, and others have begun to implement management, engineering, and financial programs that will ultimately help GWA to become a sustainable utility. Specific examples include the reorganization of the Engineering Division, the 2010-2014 CIP Program document, the Five-Year Financial Plan, and the further development of decision-making tools such as geographic information systems (GIS) and hydraulic models. These accomplishments and their continued improvement should be commended and supported by all GWA staff and the Consolidated Commission on Utilities (CCU) because the successful implementation of the CIP Program and financial plan cannot depend solely on the newly appointed management.

Despite these recent accomplishments, however, GWA has to address its legacy of deferred maintenance of its infrastructure and treatment facilities. The utility is now faced with having to replace much of its system in order to meet current demands and regulatory requirements, placing a disproportionate burden on its current service population. These challenges are exacerbated by the proposed military buildup, which will impose still more burdens on the utility.

PG's recommendations for how GWA can move forward are summarized in this executive summary, and the findings and recommendations are discussed further in the body of the report. The recommendations are intended to provide a road map for GWA to build upon its recent accomplishments, to correct the problems and deficiencies that yet remain, and to meet the significant challenges that lie ahead.

PG's overall recommendations can be summarized as follows:

- Changes in operation and maintenance of existing and future facilities
- Changes in planning, prioritization, and costing of capital improvement projects
- Changes to address staffing shortages
- Changes in construction management
- New strategies for financing operations and capital improvement projects.

In addition, GWA must find a way to institutionalize these changes and strategies and develop effective internal policies and procedures to ensure their endorsement, use, and frequent update.

#### *Operation and Maintenance*

GWA's key goals are to provide safe and reliable service to its customers, reduce water loss, meet and maintain compliance with regulatory permits, and increase operation and maintenance (O&M) funding. GWA has improved the reliability of its water distribution system and is making progress in its leak-detection program. Reportedly more than 11,000 leaks were repaired in 2007 alone.<sup>1</sup> Efforts are under way to repair faulty meters, which should improve the accuracy of invoices and bill collection. In late 2009, however, \$16.8 million in receivables were 61 days or older. Reducing this delinquency is fundamental to funding ongoing O&M and to securing lower-cost financing for necessary capital improvement needs.

GWA needs to develop and implement a prevention-based O&M program. Lack of preventive maintenance has been a key impediment to sustainability, and the implementation of a large number of CIPs will not make GWA a sustainable utility. GWA's Performance Management Contractor, Veolia Water Guam LLC (Veolia), which is tasked with O&M of the six WWTPs and the wastewater collection and conveyance system, has initiated a limited preventive maintenance program for the wastewater system. The preventive maintenance program has been limited because of a lack of funding. That O&M program should be significantly expanded and then emulated within the water system.

#### *Planning, Prioritization, and Costing of Capital Improvement Projects*

PG recommends that GWA improve its planning and decision-making tools to better identify and prioritize its capital projects. In this report, PG evaluates several water and wastewater projects and identifies several shortcomings in GWA's planning process. For example, the Moratorium project raises questions regarding GWA's processes for diagnosing a problem in its system and its ability to design the most cost-effective

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<sup>1</sup> Joint Guam Program Office, *Draft Environmental Impact Statement/Overseas Environmental Impact Statement, Guam and CNMI Military Relocation*, Vol. 6, Chap. 3, p. 3-12 (November 20, 2009).

remedy. In this particular example, GWA engineering staff did not adequately consider alternative options, some of which might have provided a more technically sound and cost-effective solution. Such oversights can be avoided in the future by ensuring that all projects are subjected to peer and management consultation and review.

PG recommends that GWA further evaluate the current inventory of planned wastewater system projects and programs and potentially reprioritize or modify the inventory of planned projects. The costs for projects programmed for advancement should be reassessed, validated, and thoroughly documented to allow for future review. Likewise, a stepwise project identification and prioritization process is required in order to develop a specific list of projects to be accomplished as a component of the recurring wastewater and water system programs.

In addition, PG recommends that GWA prepare a revised and detailed Needs Assessment based on the Guam and CNMI Draft EIS/OEIS publicly available and any additional information GWA has received regarding the NDWWTP, population projections, and water demands and delivery. As part of this effort, the Needs Assessment should include technically and financially sound, transparent, and substantiated needs in response to the military buildup.

The use of sound and disciplined cost estimation principles is of paramount concern for GWA because of the cascading impact on projects, budgets, and financial planning. As discussed throughout this report, PG was not able to validate GWA's 2010–2014 CIP and Additional Needs cost estimates because of a lack of written cost estimation processes and supporting documentation. PG recommends that GWA work aggressively to develop and institutionalize project and program cost estimation principles at the earliest opportunity. It is recommended that GWA develop these principles as a component of the re-costing necessary for the 2010–2014 CIP projects and the Needs Assessment. This would also prompt GWA to locate historical documents and data and to implement a new record-keeping initiative to maintain this important information.

Furthermore, GWA needs to incorporate industry standards and management tools, such as hydraulic models, GIS, and asset and maintenance management procedures, and should allocate resources and training to ensure their successful development and implementation. These tools should be rapidly developed, institutionalized, and implemented.

### *Staffing Shortages*

GWA's is chronically understaffed and has difficulty attracting and retaining qualified staff. Existing staff are consumed with keeping the utilities operating from day to day. It is unlikely that they will have the time or resources to adequately plan for the military buildup. As an alternative, PG recommends that GWA obtain independent engineering support to work directly with GWA to (1) identify and substantiate additional infrastructure needs associated with the military buildup; (2) establish a schedule identifying the sequence of additional needs planning, design, and construction activities; and (3) develop criteria and subsequently promote an apportionment of the associated costs to GWA and the military. This process would start as soon as possible and extend throughout the military buildup planning process.

PG believes the engineering, design, construction oversight, and contract management associated with GWA's planned CIP and the military buildup will require extensive technical and administrative resources not readily available to GWA. GWA has identified the need for additional professional services in its Additional Needs request.

### *Construction Management*

Previously, the GWA senior engineers were in charge of managing specific projects, with only limited coordination between them. Conversations with key engineering staff indicate that much if not all of the contracting risk has been shifted to GWA, rather than the contractors. This shift has resulted in frequent and large-value claims submitted by contractors. To remedy this situation, the Chief Engineer has begun to transition contracting responsibilities from engineering to the engineering support staff section. Effective, industry-standard contract language is to be developed and reviewed by legal staff to ensure that risks are appropriately placed on contractors, not on GWA. PG strongly encourages GWA to complete this activity because it will help to ensure consistency, reduce risk, and increase the efficiency of the contracting process.

In particular, PG recommends that GWA adopt the Standard Terms & Conditions and other supporting documents for construction projects developed by the Engineer's Joint Construction Documents Committee (EJCDC). With regard to technical specifications, PG suggests that GWA significantly strengthen its specifications for installation testing and for measurement/payment for completed construction work. Finally, PG recommends increasing construction inspection diligence by (1) ensuring there is full-time inspection for all active construction, particularly underground work; (2) ensuring inspectors are adequately trained to understand the correct installation procedures for the construction work they are observing; (3) developing a "reward/penalty" system for inspectors that is linked directly to the contractor's success in passing work performance testing; and (4) ensuring GWA senior staff more actively participate in construction by regularly visiting construction sites and interacting with the on-site construction inspectors. Another key to effective construction management is competent construction cost estimating throughout project planning, design, and construction. PG recommends that GWA increase staff awareness and knowledge of appropriate cost-estimating techniques as well as standardize its cost-estimating procedures and cost estimate documentation/maintenance.

### *Strategies for Financing Operations and Capital Improvement Projects*

PG recommends that GWA adopt a standardized utility financial planning methodology that takes a bottom-up approach to assessing funding requirements. This process should begin by identifying capital and O&M needs and determining the appropriate user rate and financing approaches to fund those needs. Moreover, GWA should consider developing various scenarios and financial plans for the military buildup to ensure that it will be able to access funds more quickly when plans are finalized and begin construction as soon as possible.

Because GWA's current bond rating is BB, its interest rates are high. Improvements in the operation and management of the utility over time will likely result in an improved bond rating. For the near term, however, alternative financing mechanisms should be considered. Possible strategies are outlined in a memorandum to EPA from PG's subcontractor, Northbridge Environmental, attached to this report. They include:

- Cost sharing with federal agencies or other partners
- Bond bank
- Infrastructure bank
- Federal credit assistance
- Revolving loan fund
- Federal guarantee
- Build America bonds
- Government-sponsored enterprise
- Development bank
- Private equity.

In summary, PG recommends that GWA aggressively develop effective and disciplined CIP, preventive O&M, and financial programs.

# Guam Waterworks Authority Master Planning Technical Assessment

## 1.0 Purpose and Background

PG Environmental, LLC, (PG), under contract to U.S. EPA Region 9, Water Division, was tasked to conduct an assessment of the Guam Waterworks Authority's (GWA's) master planning activities, including the management of the planning programs, the 2010–2014 Capital Improvement Project (CIP) plan, and the recently submitted "Guam Waterworks Authority, Needs Assessment for Anticipated Guam Military Build-Up" (September 1, 2009) (Needs Assessment). The findings in this assessment report are based on PG's review of key, contemporary planning documents and intensive meetings with GWA staff and officials during the week of November 9, 2009.

### 1.1 Purpose of Assessment

GWA has had a history of non-compliance with federal and territorial water statutes. The water distribution system often exceeded the Maximum Contaminant Levels for microbial contaminants, and "boil notices" were common. The wastewater treatment plants, including the Northern District Wastewater Treatment Plant (NDWWTP), the Agana WWTP (a.k.a. Hagatna WWTP), and others, remain in continual violation of their National Pollutant Discharge Elimination System (NPDES) permit limits. In response to these violations, the Department of Justice filed suit against GWA in December 2002. In June 2003, the Court entered a Stipulated Order for Preliminary Relief for Civil Case No. 02-0035. Among other things, the Stipulated Order required GWA to hire qualified technical staff in key positions, including the General Manager, Chief Engineer, and Chief Financial Officer. The positions were filled, in accordance with the Stipulated Order requirements. GWA's challenges have been further exacerbated by the lack of an effective and holistic financial plan and a disproportionate amount of unfulfilled needs in comparison to the island's service population.

More recently, the Department of Defense has announced an anticipated military buildup that could increase the island's population considerably with an increase in temporary construction workers, military personnel and their dependents, and other associated growth. The anticipated military buildup will place an increased burden on GWA's water and wastewater systems.

For these reasons, PG was tasked to assess the following:

- The applicability and implementation of the GWA Water Resources Master Plan (WRMP)
- The identification, costing, and prioritization of infrastructure needs since the release of the Water Resources Master Plan (WRMP), including GWA's 2010–2014 Draft Engineering Capital Improvement Plan
- GWA's 2007 and 2009 Additional Needs requests for the anticipated military buildup

- The existence and usefulness of foundational tools necessary for current and future CIP planning programs
- GWA's financial capability to operate and maintain current and proposed infrastructure and fund the planned CIP Program and operations and maintenance (O&M) through user fees and bonds
- Identification of overarching water and wastewater system issues requiring the attention of GWA and other stakeholders.

PG's assessment of these items and its recommendations for improvement are included throughout this assessment report as appropriate.

PG and its subcontractor, Northbridge Environmental Management Consultants (Northbridge), have also produced a series of independent technical memorandums that provide detailed analysis and recommendations for the following subjects:

- Individual 2010–2014 CIP Water and Wastewater Projects and Additional Needs Associated with the Military Buildup
- Agana Main Upgrade (Moratorium) Project
- Water System Hydraulic Model
- Wastewater System Hydraulic Model
- CIP Cost Estimation and Construction Cost Control
- GWA's Financial Condition to Operate and Maintain Current, and Fund Future/Proposed, Infrastructure
- Financing Strategy for Water and Wastewater Capital Improvement Projects related to the Guam Military Buildup.

Summaries of these additional analyses are provided within the body of this report; the full analyses are provided as Appendixes 1–7.

## ***1.2 Background***

The following discussion of GWA's history was obtained from GWA's public website.<sup>2</sup>

The local public water responsibility predecessor for PUAG originated June 30, 1950 when the Congress of Guam Passed Public Law 1-12, which gave the Department of Public Works the authority to administer all utility services. In response to increased water demand and a need to expand utility services, the 1st Guam Legislature passed Public Law 1-88 on June 6, 1952 that created a new entity called the Public Utility Agency of Guam. PUAG consisted of the telephone, power, water and wastewater utilities.

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<sup>2</sup> <http://www.guamwaterworks.org/history.html>

On July 31, 1996, Public law 23-119 established the Guam Waterworks Authority to be a semi autonomous, self-supporting agency. GWA officially obtained its status on February 1, 1997.

Public law 26-76 changed the way the Guam Waterworks Authority is managed by creating an elected, non-partisan Consolidated Commission on Utilities (CCU) to oversee the operations of GWA and GPA. The five-member commission assumed policy responsibility of the two utilities from the Guam Legislature. The CCU was sworn into office on January 3, 2003 and was faced with more than \$25 million in debt and pending federal court lawsuits for numerous violations to the water and wastewater systems over the last few decades.

In the year 2003, GWA had a customer base of more than 38,000 for water and more than 24,000 for wastewater.

Figure 1 shows the current GWA organizational structure.

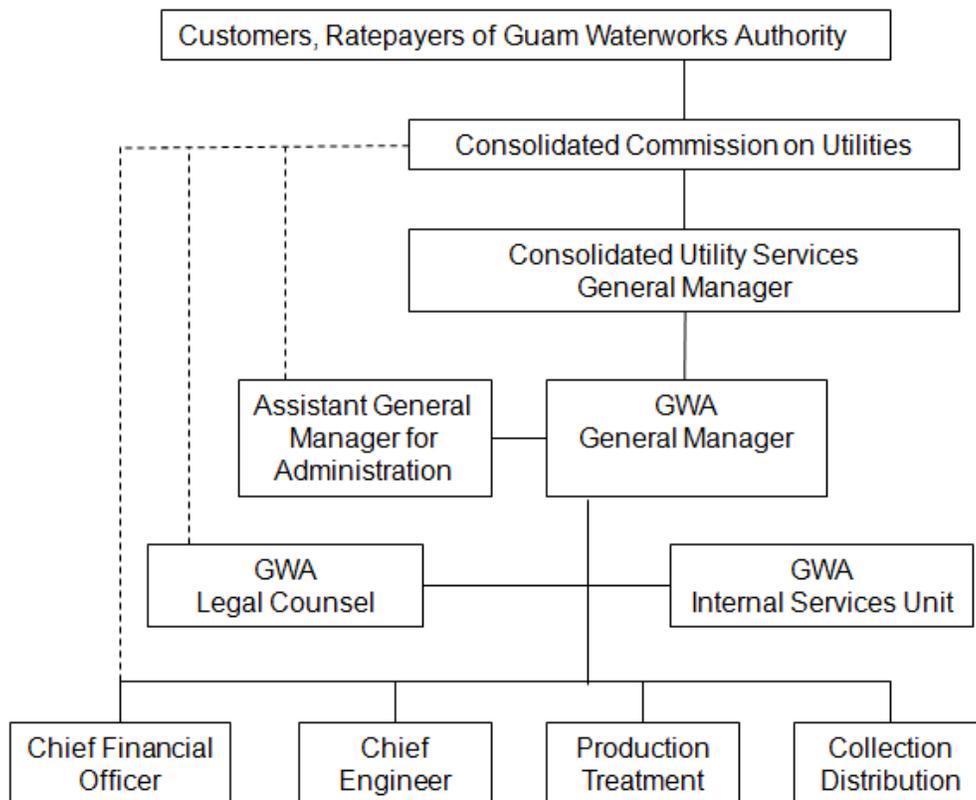


Figure 1. GWA Organizational Structure<sup>3</sup>

Dr. Leonard Olive, General Manager; Martin Roush, Chief Engineer; Greg Cruz, Chief Financial Officer; and Jesse Lujan, Assistant General Manager, as well as staff from four of GWA's 11 divisions, participated in the assessment. The following divisions participated:

<sup>3</sup> Created by PG based on [http://www.guamwaterworks.org/organizational\\_structure.html](http://www.guamwaterworks.org/organizational_structure.html).

- Engineering
- Finance
- Maintenance and Operation
- Production and Treatment.

Representatives from GWA's Performance Management Contractor, Veolia Water Guam LLC (Veolia), which is tasked with O&M of the six wastewater treatment plants (WWTPs) and the wastewater collection and conveyance system, also participated throughout the assessment.

Guam EPA also provided extensive support throughout the site visit and participated in most interviews and all visits to GWA assets. Its support was instrumental in increasing PG's knowledge of the island's water resources.

To conduct the assessment, PG assembled a team consisting of the following water and wastewater professionals:

- Wesley Ganter, Principal, PG Environmental
- Walter Grayman, P.E., Consulting Engineer
- Robert Shoff, P.E., Consulting Engineer
- Tom Rowlett, P.E., Senior Civil Engineer, PG Environmental
- Pieter Beyer, Civil Engineer, PG Environmental
- Melinda Becker, Senior Project Manager, PG Environmental
- Lisa Gomes Casseres, Senior Associate, Northbridge Environmental Management Consultants

Messrs. Ganter, Grayman, Shoff, and Beyer constituted the site visit team, which visited GWA and island stakeholders from November 9 through 17, 2009. The site visit included introductory meetings, interviews with GWA and Veolia staff, and field visits to select GWA assets. PG also attended meetings with Guam EPA, the University of Guam's Water Environmental Research Institute (WERI), and the Naval Facilities Engineering Command Pacific (NavFac Pacific). These additional stakeholder meetings were intended to provide PG with historical and current information regarding island water resources and infrastructure. A brief meeting was held with NavFac Pacific personnel to allow PG to ask questions regarding the planned military buildup.

PG was provided documents in advance of the site visit and accumulated various data, documents, and reports during the visit itself. Seven documents acquired before and during the site visit were deemed critical to completing the assessment:

1. Guam Waterworks Authority, "Draft Engineering Capital Improvement Plan 2010–2014," October 2009 (2010–2014 CIP)
2. Guam Waterworks Authority, "Needs Assessment for Anticipated Military Build-Up," September 1, 2009 (Needs Assessment)
3. Guam Waterworks Authority, Water Resources Master Plan, 2006 (2006 WRMP)

4. Veolia Water Guam, "Capital Improvement Projects and Performance Improvement Projects (CIP/PIP)," June 2007 (Veolia CIP/PIP)
5. Veolia Water Guam, "CIP/PIP Review 2008 Status Update," November 2008 (Veolia CIP/PIP)
6. Guam Waterworks Authority - 2009 Five-Year Financial (Rate) Plan, July 27 2009 (2009 Financial Plan)
7. Veolia Water Guam LLC - Agana Main Upgrade Stage 2 Functional Design Report, September 2009 (Moratorium Project Report)

It should be noted that all but the 2006 WRMP and Moratorium Project report are considered living documents undergoing frequent revision. For ease of reference, PG used the documents in the form they were in during the site visit. PG acknowledges, however, that some of the comments and suggestions in this assessment might already have been addressed by GWA staff in more recent editions of these documents.

Throughout the assessment process PG was provided unrestricted access to a wide array of GWA operational and financial data, hydraulic models, technical documents, studies and reports, GIS files, and maps, as well as access to GWA physical assets within the water and wastewater systems. GWA personnel participated actively, volunteered their time, and were generally open and candid during interviews. This open communication proved instrumental in PG's efforts to understand GWA's activities, challenges, and planned remedies. Because of GWA's efforts, PG was able to readily obtain the information and data needed to complete this report and no significant data gaps were identified. PG would like to thank GWA for its cooperation and assistance during this task.

Because some of the problems and concerns identified by PG are prevalent throughout all parts of GWA's operations, the reader may find the discussions of these problems and concerns somewhat repetitive. PG believes, however, that it is important to state its full concerns regarding each topic, however repetitive, should this document ultimately be separated into individual topic-focused sections.

The remainder of this assessment report is organized as follows:

**Section 2 - Assessment of GWA CIP Program and Process.** Provides an assessment of GWA's past and current *CIP planning process and documents* and includes PG's recommendations for their improvement.

**Section 3 - Assessment of GWA's Foundational Tools for Effective Decision-Making.** Provides an assessment of GWA's current and planned *CIP decision-making tools* and includes PG's recommendations for process and tool improvements.

**Section 4 - Assessment of GWA's Financial Capability to Operate and Maintain Current and Proposed Infrastructure and Fund the Planned CIP Program.** Provides an assessment of GWA's "2009 Five-Year Financial Plan" and its underlying assumptions.

**Section 5 - Overarching Water and Wastewater System Issues.** Identifies island-wide issues that require the immediate attention of GWA and other stakeholders.

The following appendices are also provided as stand-alone technical memorandums:

- Appendix 1. Assessment of Individual 2010–2014 CIP Water and Wastewater Projects and Additional Needs Associated with the Military Buildup
- Appendix 2. Road Map for Water System Hydraulic Model
- Appendix 3. Assessment and Recommendations for the Agana Main Upgrade (Moratorium) Project
- Appendix 4. Road Map for Wastewater System Hydraulic Model
- Appendix 5. Road Map for Improved CIP Cost Estimation and Construction Cost Control
- Appendix 6. Assessment of GWA's Financial Condition to Operate and Maintain Current and Proposed Infrastructure
- Appendix 7. Financing Strategy for Water and Wastewater Capital Improvement Projects Related to the Guam Military Buildup

## **2.0 Assessment of GWA CIP Program and Planning Process**

This section of the assessment report provides an analysis of GWA's CIP Program and planning process as embodied in the 2006 WRMP, Veolia CIP/PIP, 2010–2014 CIP, and Additional Needs documents. Additional analyses are provided regarding GWA's O&M needs and CIP-oriented financial planning. The discussion of each document is followed by summary recommendations.

### ***2.1 Basis and Validation of 2006 WRMP***

PG reviewed the 2006 WRMP and its associated appendixes and subsequently interviewed GWA and Veolia staff regarding its implementation status and usefulness to the organization. It should be noted that in most cases, the staff present during the assessment, including the General Manager, Chief Engineer, and Chief Financial Officer, had been hired since the creation of the WRMP. The following are general observations and findings from the assessment:

- Although select projects from the WRMP had been included in the 2010-2014 CIP report and GWA was using the WRMP for its five-year planning and bond funding, the WRMP was not being used as envisioned when it was created. For example, the document was not being used or viewed as a living document; in fact, it has not been modified or updated since its development. The stated purpose of the 2006 WRMP was to accomplish the following five goals:
  1. Institute sound asset management and capital planning.
  2. Develop a foundation for sound management, O&M, and financial planning.

3. Engage GWA's customers to achieve the appropriate level of service.
4. Achieve long-term resource sustainability.
5. Establish the road map for full regulatory compliance.

As of November 2009 and as documented in this report, GWA had not achieved the goals and was not following a path to achieve them.

- GWA staff were not well versed on the origin and current whereabouts of the underlying data used for project identification and cost estimation purposes. Consequently, neither GWA nor PG could validate the included cost estimates. Nor did staff have information in their possession that would allow for validating, updating, or recalculating costs. GWA staff presumed that the underlying data might have been archived within GWA or might reside with the WRMP author (Brown and Caldwell); nonetheless, it was not available to staff.
- Several sections of Volume 1 of the WRMP, which were intended to guide future CIP planning efforts, were not being followed, nor were their contents well known. These include, but are not limited to, Chapters 1-02 Planning Requirements, 1-03 Organizational Assessment, 1-04 Service Level, 1-05 Strategic Communication Plan, 1-10 CAPE, 1-14 Financial Program, and 1-15 CIP Program. This is important because these sections of Volume 1 were specifically intended to provide GWA with:
  - An assessment of affordability and early gains (1-02)
  - A road map for the acceptance and implementation of the 2006 WRMP through improvements to GWA's organizational structure and practices (1-03)
  - A guide for GWA to develop performance measures to help meet its service levels and measure operational performance (1-04)
  - A communication plan to lay the foundation between the community and GWA employees for planning efforts (1-05)
  - Implementation of a software package to help manage data records and analyze the data for capital improvement planning (1-10)
  - A financial plan for funding CIP projects (1-14)
  - Recommendations on advancing the 2006 WRMP CIP projects and developing new projects to implement (1-15).
- Sections of the WRMP process that appear to provide ongoing benefit are (1) the skeletonized water and wastewater system hydraulic models, (2) the GIS database, (3) portions of the water and wastewater system asset characterizations, and (4) the resulting general and specific needs assessment and preliminary project identification. However, deficiencies were identified with these components; they are further described in Section 3 of this report.
- Volume 2 of the WRMP ("Drinking Water") provides an overview of the existing and planned pumping, treatment, and distribution system components of the GWA potable water systems. It also describes the development and application of a water system hydraulic model of the existing and planned water systems. The plan includes great detail and recommended CIPs for specific water distribution line repairs and replacements, proposed new transmission lines, pressure zone realignments, and other projects.

Nevertheless, there are deficiencies in Volume 2 that prevent it from being used for current and future CIP selection. Specifically, the WRMP identifies providing sufficient water quantity and pressure to meet minimum fire flow requirements as the primary criterion for selecting many of the specific water system CIPs. Although in some cases this might be an appropriate and reasonable criterion upon which to base CIPs (e.g., replacement of grossly undersized pipe such as 2-inch pipe with appropriately sized pipe), it is not appropriate in all cases (e.g., incremental increases in pipe size, such as upgrading 6-inch pipe to 8-inch, strictly to meet fire flow); i.e., it does not consider all goals and priorities and is not an appropriate criterion for selecting the most critical and highest-priority CIPs. In addition, the hydraulic model of the GWA water system has not been sufficiently field-checked, calibrated, or validated, such that it can be confidently used to assess the present or future performance of the distribution system.

- The WRMP has not been updated in an attempt to address the potential impacts on the water and wastewater systems from the military buildup. Although it is understandable that this issue was not well developed in the WRMP because it was not known at that time, it is now of paramount concern to GWA and should now be reflected in a master plan document.
- The WRMP includes a placeholder CIP to address ramifications from a Ground Water Under the Direct Influence of Surface Water (GWUDI) designation for wells on all or part of the island. The document will need to be updated when final GWUDI decisions are made.
- The authors of the WRMP routinely express their belief that GWA itself needs to take ownership and maintain an active role in further developing and implementing the various planning tools and processes if the WRMP is to be successful. Unfortunately, this has not occurred, even though considerable resources were expended in developing the WRMP.
- The WRMP fails to provide a strategic vision and clearly defined set of goals for the water and wastewater systems and for the GWA organization as a whole. This statement is not intended to be a criticism of the WRMP authors because it is GWA, not the WRMP consultant, that needs to define, articulate, and embrace the vision and goals.
- The WRMP does not include a thorough discussion of the importance of and need for improved O&M of existing facilities, the tools or programs to support those needs, or an assessment of staffing needed to support adequate O&M. While it is understandable that the document focuses predominantly on capital needs, a robust discussion and plan for systematic improvement in O&M of existing and new assets need to be included.

It was clear to PG that the 2006 WRMP was not being used as an effective and dynamic planning document, and therefore an exhaustive review of its usefulness and implementation was not performed.

## 2.2 Basis and Validation of Veolia CIP/PIP Assessments

GWA hired Veolia as the Performance Management Contractor (PMC) in 2006. As part of its due diligence, Veolia assessed the capital and operational needs of the wastewater collection and treatment systems and articulated these needs in the CIP/PIP document dated June 2007. The Veolia CIP/PIP identifies the driver for a particular need in terms of three categories: (1) Condition, (2) Capacity, and (3) Risk/Health and Safety. Under these categories, each CIP/PIP is provided a priority rating of URGENT, Priority 1, Priority 2, or Priority 3.

The Veolia CIP/PIP document states that the report is to provide GWA with a definitive list of CIP/PIP to be completed or initiated over the first three years of the GWA Wastewater System PMC. This did not occur as planned, and Veolia produced a second and revised CIP/PIP document in July 2008. The document was updated to reflect a re-prioritization of projects that had occurred the previous year because of the limited amount of funds that GWA was able to secure for the Veolia CIP/PIP projects. Veolia notes that it was able to deliver only less than 5 percent of the projects because of funding shortages, which affected how remaining projects were prioritized.

PG performed a review of both Veolia CIP/PIP documents (1) to understand and assess the identified needs and (2) to evaluate the process by which the CIP/PIP or individual projects are included within the GWA CIP program. Table 1 provides a summary of the identified capital and operational needs as provided in the July 2007 Veolia CIP/PIP document. PG was not able to acquire the project costs associated with the 2008 updated CIP/PIP.

PG did not attempt to validate these costs because they had been created as a component of Veolia's due diligence process for the PMC.

**Table 1. Summary of Veolia CIP/PIP Costs by Type and Priority<sup>4</sup>**

Project Type	Priority 1	Cost Estimate	Total
WWTP	Urgent	\$580,000	<b>\$13,285,000</b>
	Priority 1	\$12,705,000	
Lift Station	Urgent	\$1,085,000	<b>\$24,240,000</b>
	Priority 1	\$23,155,000	
Collection System	Urgent	\$260,000	<b>\$290,000</b>
	Priority 1	\$30,000	
Other	Urgent	\$445,000	<b>\$6,270,000</b>
	Priority 1	\$5,825,000	
<b>All Urgent Projects Subtotal</b>		<b>\$2,370,000</b>	<b>\$44,085,000</b>
<b>All Priority 1 Projects Subtotal</b>		<b>\$41,715,000</b>	

Once on the island, PG discussed the contents, projects, and needs with various Veolia, GWA, and Guam EPA representatives throughout the site visit. These discussions included tours of the Northern District, Agana, Agat-Santa Rita, Umatac-Merizo,

<sup>4</sup> Table created by PG based on data presented in 2007 Veolia CIP/PIP Review, Appendix A.

Inarajan, and Baza Gardens WWTPs. Veolia personnel explained that the much-needed and anticipated capital projects had yet to be funded, but several grants and a few select capital programs (primarily related to collection system improvements) were under way. Therefore, the CIPs identified in the 2008 CIP/PIP document remained unchanged and many had been included in the 2010–2014 CIP.

It was also stated, however, that site conditions and operational performance at the lift stations and WWTPs had recently improved in large part because of improvements in staff morale, ownership, and placement. In some instances, modified structural improvements had been made and several American Reinvestment and Renewal Act (ARRA)-funded capital projects, such as improved aeration and grit handling, were scheduled to occur. Collection system cleaning and inspection had begun to reduce the occurrence of sanitary sewer overflows (SSOs), and longstanding lift station failures and their resulting overflows had been reduced. Veolia personnel explained that a lack of funding has restricted their ability to implement a more comprehensive preventive maintenance program, yet they characterized the recent accomplishments as “gradual improvement.”

Notwithstanding these operational improvements, significant capital and operational needs were readily apparent. For example, both the Northern District and Agana WWTPs routinely exceed their NPDES permit limits. The Agat-Santa Rita WWTP is hydraulically overloaded due to excessive inflow and infiltration, and therefore it is frequently forced to bypass treatment units altogether; SSOs routinely occur due to system blockages and/or lift station failures throughout the system.

Importantly, PG determined that although the CIP/PIP documents and associated needs are technically valid, Veolia’s assessment purposefully excludes long-term capital needs for the wastewater system. For example, the document itself states that the “growth related impacts on the system are excluded from this report” and that “the CIP’s and PIP’s identified in this report are what we believe are required to bring the individual WWTP’s in line with previous expired NPDES permits.” Therefore, the document does not include the long-term system needs associated with regular projected population growth or the planned military buildup.

Likewise, the CIP/PIP document does not fully describe long-term maintenance and operational needs. For example, the CIP/PIP request is missing enhanced and industry-norm preventive maintenance; significantly improved system characterization, cleaning, and rehabilitation; a more robust fats, oils, and grease program; and enhanced unit process controls. Veolia deserves credit for initiating an asset inventory and preventive maintenance program, but the CIP/PIP fails to clearly identify these needs. Whether these needs have been expressed elsewhere is unknown.

In summary, although the CIP/PIP document provides a sound and well-documented starting point for capital improvements, it fails to represent the true capital, maintenance, and operational needs. In addition, only a very small percentage of these needs have been met.

## 2.3 Basis and Validation of 2010- 2014 CIP Projects and Costs

### 2.3.1 Contents of 2010-2014 CIP Document

In the 2010–2014 CIP report dated October 2009, the Chief Engineer laid out a proposed Engineering Capital Improvement Plan for the period 2010 through 2014. Though this was still to be considered a draft document, it was at the time the most authoritative listing of proposed projects for the next five years.<sup>5</sup> The General Manager stated that prior to the creation of the 2010–2014 CIP report, the WRMP had been the most complete planning document and no traditional 5- or 10-year CIP plan and document had existed within GWA. The Chief Engineer stated that the document was an attempt to identify, characterize, and explain all the ongoing and planned CIP projects in one document and that improvements in its completeness and utility were forthcoming. PG applauds the Chief Engineer’s efforts to create the 2010–2014 CIP report.

The document includes a summary table comprising Potable Water, Wastewater, Electrical Engineering, and Miscellaneous projects for the years 2010, 2011, 2012, 2013, and 2014. The following five tables provide a summary of all 2010–2014 CIP projects from the document. Within each primary category, each project is assigned a CIP ID number based on the form XX-YY-ZZ, where

- XX refers to Potable Water (PW), Wastewater (WW), Electrical (EE), or Miscellaneous (MC)
- YY refers to the initial or planned funding year (e.g., 05 = 2005)
- ZZ is a unique sequence number for the funding year.

**Table 2. Summary of 2010–2014 GWA CIP Projects by Service Category<sup>6</sup>**

<b>2010–2014 CIP Projects Summary</b>	
Potable Water Projects	\$88,632,000
Wastewater Projects	\$121,136,000
Electrical Projects	\$12,450,000
Miscellaneous Projects	\$18,592,000
<b>Total</b>	<b>\$349,496,000</b>

**Table 3. Summary of Individual 2010–2014 GWA CIP Potable Water Projects<sup>7</sup>**

<b>ID</b>	<b>Potable Water Projects</b>	<b>2010-2014 Total</b>
PW 05-01	Ground Water Disinfection	<b>\$757,000</b>
PW 05-02	Water Reservoir Condition Assessment	<b>\$430,000</b>

<sup>5</sup> It should be noted that PG was provided the 2010–2014 CIP document immediately before conducting the site visit. Only during the on-site kickoff meeting was PG informed that the document represents GWA’s most current CIP planning effort.

<sup>6</sup> Recreated by PG based on the tables provided in the October 2009 2010–2014 CIP.

<sup>7</sup> Recreated by PG based on the tables provided in the October 2009 2010–2014 CIP.

PW 05-03	Santa Rita Springs Booster Pump Rehabilitation, Phase II	<b>\$429,000</b>
PW 05-04	Ugum Water Treatment Plant Refurbishment	<b>\$3,000,000</b>
PW 05-05	"A" Series Well Transmission Line	<b>\$500,000</b>
PW 05-06	Water Booster Pump Station	<b>\$1,200,000</b>
PW 05-07	Meter Replacement Program	<b>\$7,500,000</b>
PW 05-08	Barrigada Tank Repair/Replacement	<b>\$2,500,000</b>
PW 05-09	Leak Detection / Line Repair	<b>\$3,950,000</b>
PW 05-10	Potable Water System Planning	<b>\$200,000</b>
PW 09-01	Ugum Water Treatment Plant Intake Modifications	<b>\$620,000</b>
PW 09-02	Water Wells	<b>\$3,356,000</b>
PW 09-03	Water Distribution System Pipe Replacement	<b>\$14,300,000</b>
PW 09-04	Pressure Zone Realignment/Development 2005 Improvements	<b>\$3,450,000</b>
PW 09-05	Northern Water Distribution System 2005 Improvements	<b>\$5,300,000</b>
PW 09-06	Central Water Distribution System 2005 Improvements	<b>\$1,500,000</b>
PW 09-07	Southern Water Distribution System 2005 Improvements	<b>\$2,450,000</b>
PW 09-08	Mechanical/Electrical Equipment Replacement	<b>\$1,790,000</b>
PW 09-09	Water Reservoir Internal/External Corrosion Assessment	<b>\$500,000</b>
PW 09-10	Water Reservoir Internal/External Corrosion Rehabilitation	<b>\$3,200,000</b>
PW 09-11	Water System Reservoir 2005 Improvements	<b>\$23,200,000</b>
PW 11-01	Distribution System Upgrades	<b>\$3,800,000</b>
PW 11-02	Ugum Water Treatment Plant Reservoir Replacement	<b>\$4,700,000</b>
<b>Total</b>		<b>\$88,632,000</b>

**Table 4. Summary of Individual 2010–2014 GWA CIP Wastewater Projects<sup>8</sup>**

ID	Wastewater Projects	2010-2014 Total
WW 05-01	Old Agat Wastewater Collection (I&I Reduction)	<b>\$2,200,000</b>
WW 05-02	Collection Line Upgrade/Collection System Upgrades	<b>\$3,800,000</b>
WW 05-03	NDWWTP Diffuser Installation	<b>\$3,000,000</b>
WW 05-04	Wastewater System Planning	<b>\$200,000</b>
WW 05-05	Wastewater Vehicles	<b>\$235,000</b>
WW 05-06	Wastewater Pump Station Upgrades	<b>\$225,000</b>
WW 05-07	NDWWTP - Chlorine Tanks	<b>\$250,000</b>
WW 05-08	Umatac-Merizo STP Improvements	<b>\$535,000</b>
WW 09-01	LS Priority 1 Upgrades	<b>\$19,400,000</b>
WW 09-02	Moratorium	<b>\$38,000,000</b>
WW 09-03	Old Agat Collection Continuation (III)	<b>\$2,200,000</b>
WW 09-04	Manhole Frame Seal Repair	<b>\$84,000</b>
WW 09-05	Agat Manhole Rehabilitation	<b>\$55,000</b>
WW 09-06	Wastewater Collection System Replacement/Rehabilitation	<b>\$3,250,000</b>

<sup>8</sup> Recreated by PG based on the tables provided in the October 2009 2010–2014 CIP.

ID	Wastewater Projects	2010-2014 Total
WW 09-07	Tumon Bay Sewer Upgrades	\$1,500,000
WW 09-08	Facilities Plan/Design for Baza Gardens STP Replacement	\$2,500,000
WW 09-09	Facilities Plan/Design for the Northern District STP Bio-Solids	\$500,000
WW 09-10	Facilities Plan/Design for Agat-Santa Rita STP Replacement	\$600,000
WW 09-11	WWTP Priority 1 Upgrades	\$9,500,000
WW 11-01	Priority 1 Sewer Upgrades - Agat District	\$500,000
WW 11-02	Priority 1 Sewer Upgrades - Baza Gardens District	\$650,000
WW 11-03	Baza Gardens STP Replacement	\$22,912,000
WW 11-04	Facilities Plan/Design for the Umatec-Merizo STP Improvements	\$140,000
WW 11-05	Facilities Plan for Agana STP Improvements & Effluent WWPS	\$1,900,000
WW 11-06	Agana STP Improvements and Effluent WWPS	\$2,000,000
WW 11-07	Northern District STP Expansion - Biosolids Electrical	\$5,000,000
<b>Total</b>		<b>\$121,136,000</b>

**Table 5. Summary of Individual 2010–2014 GWA CIP Electrical Projects<sup>9</sup>**

ID	Electrical Projects	2010-2014 Total
EE 05-01	Well Electrical Protection	\$200,000
EE 05-02	SCADA Pilot Project	\$300,000
EE 09-01	Wastewater Pumping Station Electrical Upgrade	\$2,000,000
EE 09-02	Electrical Upgrade - Water Wells	\$4,000,000
EE 09-03	Electrical Upgrade - Water Booster Pump Stations	\$650,000
EE 09-04	Electrical Upgrade - Water Booster Pump Stations	\$350,000
EE 09-05	Electrical Upgrade - Other Water Booster Pump Stations	\$250,000
EE 09-06	SCADA Improvements - Phase 1	\$250,000
EE 09-07	SCADA Improvements - Phase 2	\$1,100,000
EE 09-08	SCADA Improvements - Phase 3	\$2,500,000
EE 09-09	SCADA Improvements - Phase 4	\$850,000
<b>Total</b>		<b>\$12,450,000</b>

**Table 6. Summary of Individual 2010–2014 GWA CIP Miscellaneous Projects<sup>10</sup>**

ID	Miscellaneous Projects	2010-2014 Total
MC 05-01	Laboratory Modernization	\$1,200,000
MC 05-02	Land Survey	\$2,050,000
MC 09-01	General Plant Improvements/Water Distribution System	\$15,342,000
<b>Total</b>		<b>\$18,592,000</b>

<sup>9</sup> Recreated by PG based on the tables provided in the October 2009 2010–2014 CIP.

<sup>10</sup> Recreated by PG based on the tables provided in the October 2009 2010–2014 CIP.

Though GWA refers to all the 2010–2014 CIP line items as “projects,” it is useful to differentiate the projects as either discrete “projects” or “programs.” A project is considered a defined individual design/construction item or set of such items, with a specific endpoint and cost that can be assigned. Programs are more open-ended and can be further classified as design/construction programs, assessment programs, or planning programs. Likewise, PG acknowledges that the extent of activities undertaken within recurring programs is generally dictated by an alignment of the program budgets with fiscal constraints.

Based on discussions with GWA and review of the 2010–2014 CIP report, PG segregated the 23 potable water projects into 8 projects and 15 programs. Of the 26 wastewater projects, PG segregated the list into 18 projects and 8 programs. The breakdown of the projects and programs is provided individually in Appendix 1.

### **2.3.2 Assessment of Costs**

PG did not attempt to validate the costs provided in the 2010–2014 CIP. For the reasons provided below, PG finds that the validation of the costs is a process that only GWA can complete; it would require many resources not available to PG, which GWA should possess. A recalculation of costs would also serve as a very positive tool for GWA’s use in conducting a review of previous costing estimates and establishing a methodology that can be applied consistently for future projects.

PG found the following:

- Project costs were developed using various methodologies and frequently cannot be recreated.
- Several of the projects are actually placeholders for additional funding for GWA, meaning the project cost estimates are irrelevant because the funds would be channeled to other similar efforts, not specifically to those listed.
- Some cost estimates are engineering best-guesses that were not subject to a detailed engineering costing methodology.
- Once the projects were summed in the 2010–2014 CIP, their costs were adjusted without engineering basis to meet GWA’s fiscal constraints, and no record was kept of the costs prior to adjustment.

Because the 2010–2014 CIP represents an effort by GWA to compile all projects that are being implemented or are planned, the origins of the various projects are very different. Some projects are from the 2006 WRMP, others have their origin in the 2006 Stipulated Order, and others are still remnants of projects that began during previous GWA administrations that precede many of the employees currently working at GWA. Consequently, the manner in which the projects were planned and designed varies tremendously in the CIP. It became evident during PG’s site visit that this has especially affected the costing of the projects. GWA was not able to point to any single methodology that was used throughout the document and frequently was unable to provide supporting documentation on the history of the cost estimates. A good example of this is the projects that came from the 2006 WRMP. The projects take up a

considerable amount of the CIP budget, but GWA is uncertain about how the cost estimates in the 2006 WRMP were developed and can no longer locate the underlying data that were used to create them. PG strongly recommends that GWA work to obtain the underlying cost data and analyze the cost estimation principles used by the WRMP contractor, Brown and Caldwell.

Moreover, several of the projects in the 2010–2014 CIP that reference the 2006 WRMP as their genesis are not actually slated for implementation as described in the 2010–2014 CIP. GWA has stated that some projects are actually mere placeholders used to ensure funding for the type of activity planned under the project. The specific aspects of the project on which the costs were developed will most likely be modified once the funding becomes available. Good examples of this are “PW 09-11 Northern Water Distribution System 2005 Improvements” and “WW 11-01 Priority 1 Sewer Upgrades - Agat District.” Both of these projects cite tables in the 2006 WRMP that provide specific lines to be replaced; however, GWA has stated that the actual lines that will be replaced will most likely differ from those provided in the 2006 WRMP. The original cost estimate is rendered irrelevant because the underlying assumption and data are no longer applicable.

Another concern with the cost estimates is that some are not based on any reasonable amount of data and instead are merely engineering guesses based on the opinion of GWA staff. The cost associated with “PW 09-11 Water System Reservoir 2005 Improvements,” for example, is completely dependent on the results of an inspection of the water reservoirs that has not yet occurred. The cost estimate associated with this project therefore represents a best-guess estimate and cannot be validated. In light of the previously discussed lack of documentation on the history of the cost estimates, there might also be other costs included in the 2010–2014 CIP that are based on guesses and not on reasonable costing.

There is also a large concern regarding the manner in which costs are adjusted without engineering basis after their inclusion in the 2010–2014 CIP. GWA personnel stated that the reality of GWA’s fiscal constraints has led GWA administration to downwardly adjust the costs in the CIP as they see fit in order to meet their political and fiscal constraints. This top-down type of adjustment does not consider the actual cost required to deliver the projects. There appeared to be a general lack of record with respect to these adjustments regarding when they were made, how much the adjustments were, and what the original project cost estimates were before adjustment. This lack makes validating project costs extremely difficult because, again, the complete history of the estimate is not known.

In light of these concerns, PG found that the lack of history and data available on the cost estimates made it impossible for PG to attempt to validate the costs. PG strongly recommends that GWA commence a review of the cost estimates and revise them using a consistent methodology to reflect more recent data whenever possible. This would also prompt GWA to locate historical documents and data and to implement a new record-keeping initiative to maintain these important assets. PG provides recommendations for improved cost estimation principles in Appendix 1.

### 2.3.3 Assessment of Projects and Programs

PG interviewed GWA Engineering Division staff to more fully assess the Potable Water, Wastewater, Electrical Engineering, and Miscellaneous projects. PG's assessment contains a brief discussion of the scope of the individual projects and a general assessment regarding whether the project represents a true need and whether the proposed project would satisfactorily address that need.

The following is a summary of the complete assessment, including summary findings for the potable water and wastewater projects. The detailed project-by-project assessment and results are provided as Appendix 1 to this report.

#### ***Recommended Procedures for Assessing and Planning Potable Water Projects***

Examination of the 23 proposed projects and programs suggests that, in general, these are a valid set of projects that are consistent with the needs of the GWA water system. However, further articulation of the details of some of the projects is needed, and the cost estimates associated with the individual projects need further examination.

Furthermore, several requirements and planning steps need to be undertaken to ensure that the projects and programs result in the optimal investment strategy. These steps are and PG's associated recommendations are outlined below.

- 1. Development of a set of criteria and procedures for the selection of specific projects within programs.** As indicated above, a majority of the proposed potable water projects have been classified as construction programs that will be composed of many individual, specific projects. At this time, however, the individual projects have not been articulated, nor have the details been provided. A three-step process is required to develop a specific list of projects: (1) developing a specific set of criteria for selecting and prioritizing projects; (2) selecting and prioritizing specific projects for the coming one- to two-year funding horizon using these criteria; and (3) developing firm cost estimates of the projects. As an example of criteria, GWA has suggested that the highest-priority pipeline projects will be the replacement of 2-inch-diameter lines, existing pipelines that have experienced frequent leaks and breaks, and existing lines that have insufficient capacity to deliver required flow. For tank/reservoir improvements, results of the condition assessment and present and future storage requirements have been suggested as primary criteria.

*Recommendation: GWA should develop a more detailed and formal approach to developing and instituting such criteria as they are essential for planning purposes.*

- 2. Development of a validated hydraulic model of the water distribution system.** GWA has identified the development of a model as a key step in all future analysis of the distribution system and assessment of future projects. At this time, the model of the full system developed as part of the 2006 WRMP is inadequate to serve the required purpose for the following reasons: (1) it does

not run in extended-period simulation, and even successful use in steady-state is not dependable; (2) GWA personnel are not fully trained in the use of the software; (3) not all assumptions and aspects of the model have been fully evaluated; and (4) there has been virtually no validation of the model based on field data.

*Recommendation: A formal process for examining, calibrating, and field-validating the model is needed before it can be used with any confidence. A suggested approach for examining and upgrading the modeling capability is presented in the Road Map for Water Hydraulic Model provided as Appendix 2.*

- 3. Further analysis to better use the results of the leak-detection program.** The ongoing leak-detection program is collecting a wealth of information on the distribution system. If properly analyzed and managed, these data can serve many useful planning purposes, including update of pipe information, identification of locations of leaks, and collection and analysis of pressure and water use information. Some of this analysis is being carried out by the contractor, which supplies information on leaks to GWA in a format for direct entry into the geographic information system (GIS) database.

*Recommendation: A formal protocol for checking and using the data from the leak-detection program should be developed. Additional staff resources for GIS are also needed to efficiently update the database to represent true conditions.*

- 4. Implementation of a team approach in planning.** Water system planning and modeling require input and discussion among a wide range of personnel, including GWA representatives from the engineering, operations, GIS, modeling, and water quality areas and outside groups such as Guam EPA.

*Recommendation: A formal team approach should be formulated and adopted.*

- 5. Integration of GIS, asset management, and modeling capabilities.** There is the potential for extensive overlap in the information used or stored by GIS, asset management, and modeling.

*Recommendation: GWA should work toward the establishment of a formal integration of these three areas to ensure consistency.*

- 6. Formalization of the zonal management system.** Within the past several months, GWA has placed emphasis on defining its water distribution system in terms of basic water service areas (WSAs). A WSA can be defined as a bounded area within the distribution system that operates at approximately the same hydraulic grade line and is separated from adjacent WSAs by pumps, control valves, and/or flow meters. In effect, these are equivalent to finely defined pressure zone areas. GWA engineering is in the process of developing a “bubble map” illustrating these WSAs and estimating the water demand and production within each area. In the long run they have proposed using WSAs in a management role to track water use and water loss by metering all flow that is produced within the WSA and flow that moves between WSAs. This process is equivalent to the district metering area (DMA) concept that has been successfully

used throughout the United Kingdom for leak management and flow accounting for more than 20 years.

*Recommendation: GWA should formalize this process and use it in the future as a mechanism for tracking and reducing water loss within its system.*

- 7. Examination of the impacts of GWUDI and the military buildup on the proposed projects.** The development of the 2010–2014 CIP has largely ignored two potential events that might significantly impact GWA in the near to medium term—the proposed military buildup and the possible designation of part or all of the system as groundwater that has been determined to be under the direct influence of surface water (GWUDI). The military buildup would likely result in significant increases and spatial changes in water demand that would necessitate additional sources of water, additional delivery systems, and closer cooperation and possible integration with the military water systems. GWUDI would require additional treatment for some or all of the raw water used by GWA and could result in significant centralization of treatment and construction of extensive raw water transmission facilities.

*Recommendation: Though there is still significant uncertainty associated with both the military buildup and GWUDI, it is imperative for GWA to start developing long-term plans to consider the impact of these factors on its system and, as a minimum, examine the 2010–2014 CIP for consistency with long-term planning.*

### ***Recommended Procedures for Assessing and Planning Wastewater Projects***

Examination of the 26 proposed wastewater projects suggests that these are not an entirely valid set of projects. The projects do not appear entirely consistent with the needs of the GWA wastewater system. GWA should reassess its wastewater needs and revise both the inventory of projects and the projects' prioritization. Further analysis of the WWTP and collection system projects to occur within the Northern District and Agana service areas is warranted, and many of the cost estimates associated with the individual projects need further examination.

- 1. Concerns regarding the effectiveness of the Agana Main Upgrade (Moratorium) Project design.** A cursory review of the design revealed that there might be other alternatives that can achieve the same goal at considerably lower capital and maintenance costs. The review also revealed that the original design process might have inadequately represented the true cost to operate and maintain the system after construction, did not include a sufficiently long design-life period, and did not acknowledge the complexities of placing major sewage-handling facilities in a residential area.

*Recommendation: The Moratorium Project should be subjected to a thorough value-engineering assessment by an independent consultant to determine the merits and realism of the current design and to provide for other design alternatives that might achieve the same goal at lower cost and maintenance requirements. PG's review of the Moratorium Project is provided as Appendix 3.*

2. **WWTP facility plans and construction projects appear disjointed.** GWA has several facilities plans slated in the 2010–2014 CIP that might not properly consider ancillary or subsequent projects. There is, for example, a facilities plan and design scheduled for the Umatac-Merizo treatment plant; however, a project that provides for the rehabilitation of the treatment plant already exists.

*Recommendation: The need for the facilities plan and design projects should be reevaluated and the projects found necessary should be more effectively linked and/or sequenced with their subsequent projects.*

3. **Wastewater programs are not well prioritized.** There are numerous programs within the CIP that all serve similar purposes of system rehabilitation and renewal. The programs are as follows:

WW 05-02 Collection Line Upgrade/Collection System Upgrades  
WW 05-06 Wastewater Pump Station Upgrades  
WW 09-04 Manhole Frame Seal Repair  
WW 09-05 Agat Manhole Rehabilitation  
WW 09-06 Wastewater Collection System Replacement/Rehabilitation  
WW 11-01 Priority 1 Sewer Upgrades - Agat District  
WW 11-02 Priority 1 Sewer Upgrades - Baza Gardens District

*Recommendation: To allow better prioritization of these programs and to allow for a system-wide planning approach, it is recommended that these disparate programs be pooled into a single renewal/rehabilitation program. Within the program GWA should develop and deploy a three-step process to develop a specific list of projects: (1) develop a specific set of criteria for selecting and prioritizing projects; (2) using these criteria, select and prioritize specific projects for the coming one- to two-year funding horizon; and (3) develop firm cost estimates for the projects.*

4. **Several wastewater projects lack historical basis.** Many of the wastewater CIP projects are a direct carryover from the 2006 WRMP. GWA has stated on numerous occasions that the underlying data for some of these projects can no longer be located. This raises the concern of whether the wastewater projects in the CIP that originate from the 2006 WRMP can actually be implemented correctly and delivered as envisioned once funding becomes available.

*Recommendation: GWA should reevaluate the applicability of the 2006 WRMP using the most current asset condition data.*

5. **Known and identified needs not included in 2010-2014 CIP.** GWA and Veolia staff frequently mentioned the need for one or more dedicated septage receiving stations on the island. At the time of the site visit, septage from numerous pumpers/haulers was being discharged directly into the headworks of the Agana WWTP. This is a known reason that the plant continually violates its NPDES permit limits. GWA and Veolia representations described a temporary remedy whereby a new junction box would be constructed at the terminus of the primary clarifiers for septage receipt. The septage would then flow to the digesters with supernatant returned to the primaries. It was believed this solution could significantly improve the probability of meeting permit limits. The cost for the

junction box was thought to be less than \$10,000. This is a temporary (and unproven) fix, and a permanent solution is clearly needed. Such a solution is not included in the 2010–2014 CIP.

Other examples include the need for enhanced sewer characterization, inspection, cleaning, and rehabilitation and ultimately a plan for systematic sewer and asset replacement.

*Recommendation: In any subsequent Master Plan, GWA should identify the planned useful life of the sewer system and then design a replacement strategy that can be implemented each year to reach the ultimate goal. An example would be to determine the miles of sewer and divide it by the useful life (e.g., 50 years). This would result in the number of sewer miles that need to be replaced each year.*

6. **Several projects as they exist in the CIP are also no longer valid because the need for them either has been addressed or no longer exists.** An example is the previously mentioned Umatac Merizo facilities plan and design.

*Recommendation: GWA should evaluate which needs have been met and eliminate obsolete projects from the 2010-2014 CIP.*

### ***Summary Assessment of Electrical and Miscellaneous Projects***

The electrical projects appeared to be valid projects. Of the 13 projects evaluated, all were found to be valid projects. Specific comments include:

1. **Expedited SCADA Implementation.** GWA is currently developing and implementing a pilot-scale SCADA system and plans to design and implement a full-scale system across both the potable water and wastewater systems.

*Recommendation: Because of the many benefits a SCADA system supplies, it is in the interest of GWA to expedite the design and installation of the system to reap its benefits as soon as possible. Along with providing for better understanding and control of the GWA water and wastewater system, this system would also free up valuable staff resources that are currently spent on taking system parameter measurements. These resources could then be redirected toward other important duties, such as preventive maintenance. The SCADA system could also be designed to supply data to assist with hydraulic model calibration.*

2. **Electrical Upgrade/Maintenance Program.** Several of the projects in the CIP are electrical system upgrade and rehabilitation projects.

*Recommendation: These projects could be combined under a single program to provide an improved opportunity for prioritization and planning. Enhanced collaboration with the Guam Power Authority for this program could also be beneficial when selecting electrical equipment and determining appropriate maintenance procedures.*

## 2.4 Basis and Validation of Additional Needs Request

To prepare for the anticipated military buildup, GWA has prepared an assessment of its needs to accommodate growth it considers to be above its normal needs. The first iteration of this assessment resulted in the 2007 Needs Assessment. There have been two more iterations of that document since then—the April 2009 “Critical Wet Infrastructure Needs Assessment” and the September 2009 “Updated Needs Assessment” (2009 Needs Assessment). For the purpose of PG’s assessment, the 2009 Needs Assessment was used because it includes the most complete list of projects and represents GWA’s most recently submitted work. During the site visit GWA showed PG an in-process draft version of a revised document, which takes into consideration more recent population growth estimates supplied to GWA by the Navy but has not yet been submitted to EPA for review and consideration.

Table 7 provides all needs included in the 2009 Needs Assessment with their associated cost estimates in 2009 dollars, as well as any projects in the 2010–2014 CIP that relate to the needs and their cost estimates. Note that the need for Radial Collector Wells is now considered obsolete.

**Table 7. Summary of 2009 Needs Assessment and Related 2010-2014 CIP Projects<sup>11</sup>**

<b>2009 Needs Assessment Project</b>	<b>\$ in 2010-2014 CIP</b>	<b>\$ in 2009 Needs Assessment</b>
XX YY-ZZ = Related 2010–2014 CIP Project		
<b><u>Water Projects</u></b>		
<b>16 New Water Wells</b>		<b>\$12,941,787</b>
PW 09-02 Water Wells	\$3,356,000	
<b>GWUDI</b>		<b>\$20,814,707</b>
<b>Distribution Line Replacement</b>		<b>\$43,139,290</b>
PW 05-09 Leak Detection / Line Repair	\$3,950,000	
PW 09-03 Water Distribution System Pipe Replacement	\$14,300,000	
<b>Ugum Raw Water Intake Modifications</b>		<b>\$593,165</b>
PW 09-01 Ugum Water Treatment Plant Intake Modifications	\$620,000	
<b>Southern Booster Station Modifications</b>		<b>\$2,426,585</b>
PW 05-06 Water Booster Pump Station	\$1,200,000	
<b>Steel Reservoir Corrosion Repairs</b>		<b>\$2,156,965</b>
PW 05-08 Barrigada Tank Repair/Replacement	\$2,500,000	
PW 09-09 Water Reservoir Internal/External Corrosion Assessment	\$500,000	
PW 09-10 Water Reservoir Internal/External Corrosion Rehabilitation	\$3,200,000	
PW 09-11 Water System Reservoir 2005 Improvements	\$23,200,000	
<b>Northern Distribution Improvements</b>		<b>\$7,851,351</b>
PW 09-05 Northern Water Distribution System 2005 Improvements	\$5,300,000	
<b>Central Distribution Improvements</b>		<b>\$2,005,977</b>

<sup>11</sup> Created by PG based on data provided in the 2009 Needs Assessment Update and the 2010-2014 CIP.

<b>2009 Needs Assessment Project</b>		<b>\$ in 2010-2014 CIP</b>	<b>\$ in 2009 Needs Assessment</b>
XX YY-ZZ = Related 2010–2014 CIP Project			
PW 09-06	Central Water Distribution System 2005 Improvements	\$1,500,000	
<b>Southern Distribution Improvements</b>			<b>\$11,863,305</b>
PW 09-07	Southern Water Distribution System 2005 Improvements	\$2,450,000	
<b>Northern Raw Water Transmission Line</b>			<b>\$37,444,904</b>
<b>Radial Collector Wells</b>			<b>Obsolete</b>
<b>Water Subtotal</b>		<b>\$62,076,000</b>	<b>\$141,238,036</b>
<b><u>Wastewater Projects</u></b>			
<b>Agat Treatment Plant</b>			<b>\$58,000,000</b>
WW 09-10	Facilities Plan/Design for Agat-Santa Rita STP Replacement	\$600,000	
<b>Northern Plant Expansion</b>			<b>\$130,025,823</b>
<b>Northern Collection System Upgrades</b>			<b>\$7,180,000</b>
WW 05-02	Collection Line Upgrade/Collection System Upgrades	\$3,800,000	
<b>Central Collection System Upgrades</b>			<b>\$4,000,000</b>
WW 05-02	Collection Line Upgrade/Collection System Upgrades	\$3,800,000	
<b>Northern District Diffuser</b>			<b>\$7,000,000</b>
WW 05-03	Northern District Diffuser Installation	\$3,000,000	
<b>Wastewater Subtotal</b>		<b>\$11,200,000</b>	<b>\$206,205,823</b>
<b><u>Common-Issues Projects</u></b>			
<b>SCADA Control System</b>			<b>\$5,068,867</b>
EE 05-02	SCADA Pilot Project	\$300,000	
EE 09-06	SCADA Improvements - Phase 1	\$250,000	
EE 09-07	SCADA Improvements - Phase 2	\$1,100,000	
EE 09-08	SCADA Improvements - Phase 3	\$2,500,000	
EE 09-09	SCADA Improvements - Phase 4	\$850,000	
<b>Outsourcing of Professional Services</b>			<b>\$808,862</b>
<b>Planning Studies</b>			<b>\$1,200,000</b>
PW 05-10	Potable Water System Planning	\$200,000	
WW 05-04	Wastewater System planning	\$200,000	
<b>Common Issues Subtotal</b>		<b>\$5,400,000</b>	<b>\$7,077,729</b>
<b>Total</b>		<b>\$78,676,000</b>	<b>\$354,521,588</b>

Similar to the potable water and wastewater assessment approach, PG interviewed GWA Engineering Division staff to more fully assess the Additional Needs and then applied the same evaluation criteria. The following is a summary of the assessment, including findings for the Additional Needs projects. The detailed results of these assessments are provided as Appendix 1.

### ***Summary Assessment of Additional Needs Projects***

Following examination of the 18 proposed projects, PG found it exceedingly difficult to substantiate the stated needs and associated costs. Many of the needs appear valid, but GWA needs to make an effort to more thoroughly convey and substantiate the needs linked to impacts associated with the military buildup. Specific comments follow.

1. GWA noted during the site visit that the needs assessments were created on a very limited schedule and without accurate data. A specific piece of information that the military did not supply to GWA until after the 2009 Needs Assessment was an accurate estimate of the population increase associated with the military buildup. This greatly influences the validity of any of the cost estimates presented in the 2009 Needs Assessment because although the needs may be valid, the scope of work required to address the needs might be under- or over-estimated.
2. The cost estimation processes used by GWA to calculate the costs of the Additional Needs varied greatly. Many estimates, for example, were taken directly from the 2006 WRMP, whose costs in many cases cannot be recreated. Other cost estimates appeared to be engineering best-guess estimates that were not subjected to peer or management-level engineering review. GWA provided an Excel spreadsheet used for calculating the new water wells, line replacements, and water reservoir repair/replacement. The calculations used for these estimates were very rudimentary and applied broad assumptions that require additional assessment and refinement. Because of these weaknesses, PG did not attempt to validate any of the costs in the 2009 Needs Assessment.
3. GWA has chosen to articulate the Additional Needs in independent documents with limited relationship to the 2010-2014 CIP. This has led to confusion amongst stakeholders and potentially a misrepresentation of costs.
4. The Additional Needs documents fail to convey the basis of the need, how the costs were calculated, and how those needs have (or should be) apportioned in response to the military buildup.
5. Similar to the 2006 WRMP and the 2010–2014 CIP, the Additional Needs documents do not contain the O&M needs associated with the capital projects.
6. The Additional Needs are not prioritized and/or sequenced to reflect the anticipated stages of the military buildup. Specifically, not all of the needs will come due at the same time, and therefore PG recommends that GWA identify a logical sequence for design and build.

### ***2.5 Operation and Maintenance Program Needs Are Not Expressed***

GWA will not be able to build its way out of the current problem, nor will the implementation of a large volume of CIPs make GWA a sustainable utility. Effective and ongoing O&M is a paramount need. PG believes this is equally important to the development of an improved CIP program.

PG could not locate an assessment and compilation of GWA's O&M needs in the documents reviewed. GWA's "Five-Year Financial Plan" states an annual operating budget of \$58M. PG was informed by the General Manager and Chief Financial Officer

that managers for each of GWA's operational division's were asked to provide resource requests for their individual divisions, which when compiled equaled approximately \$70M. This request was downgraded to the \$58M mark to adhere to fiscal constraints. PG believes that the \$70M figure is likely artificially low, in part because of known staff shortages and vacancies, lack of preventive maintenance programs, lack of safety equipment and training, limited system and asset characterization, and a history of poor operating performance.

Furthermore, PG believes that the GWA divisions likely have been historically conditioned to under-report operational needs so as to align with fiscal realities and historical shortfalls in preventive maintenance. The methods by which divisions calculate, compile, and report O&M needs were not provided and therefore were not evaluated by PG. PG did not attempt to evaluate the specific O&M budgets, standard operating procedures (SOPs), and practices of each division. It is possible that efficiency gains that would allow for proper O&M to occur within the collective operations budget could be realized.

It is clear, however, that a reasonable cost estimate of the O&M needs of the GWA organization has not been documented, and whether such an evaluation has been performed is unknown.

PG recommends that GWA better identify, quantify, and document O&M needs. The following list provides examples of some of the needs that should be assessed:

- Inventory of maintenance equipment
- List of personnel with current and needed skill sets
- System maintenance manuals and associated preventive maintenance schedules
- Operation and management plan(s) for the systems and critical assets
- Spare parts inventory
- Power demands.

GWA's Performance Management Contractor, Veolia, which is tasked with O&M of the six WWTPs and the wastewater collection and conveyance system, has initiated a limited preventive maintenance program for the wastewater system. PG recommends that the existing preventive maintenance program be significantly expanded and then emulated within the water system.

Volume 1, Chapter 7, of the WRMP describes an Asset Inventory that was created for the purpose of the WRMP, as well as future inventory management. It was created using a program called InfoCollect. The inventory also contains the condition assessment used to establish projects to be implemented. An excerpt from Chapter 7 is provided below.

## 7.2 Overview

GWA owns thousands of assets, including pumps, motors, valves, buildings, and pipes. Each one has a current value and a replacement cost. Identifying these assets is critical to determining the long-term cost of a capital improvement program.

Historical data and other information about these assets are deficient. Records have been lost, nameplates have corroded, and institutional knowledge has left GWA over the years. To obtain the best possible information about GWA's assets, and to set the stage for future information management, a database was developed for on-site field collection of asset information. The data collection tool is called InfoCollect, and it was developed using Microsoft Access as the database software. InfoCollect was developed for use on tablet computers to facilitate field data collection.

Three teams were developed to collect asset information, each dedicated to a different area of data compilation:

1. The wastewater treatment plants and the Ugum Water Treatment Plant
2. The wastewater pumping stations
3. The wells, water booster pumping stations, and reservoirs

Underground assets, including pipes in the water distribution system and the wastewater collection system, were inventoried through the development of GWA's GIS, which is discussed in Chapter 9 – GIS Program.

The GWA staff interviewed during the assessment did not appear knowledgeable of the asset inventory, and it was unclear to PG whether the inventory had been used to develop maintenance schedules or perform asset condition assessments. PG recommends that GWA reevaluate the asset inventory provided in the WRMP and assess its usefulness for developing preventive maintenance work orders and for facilitating water and wastewater program activity criteria development and project identification.

## 2.6 Financial Planning and Impact on Capital Needs

In 2009 GWA completed its "Five-Year Financial Plan," which is intended to closely align with the 2010–2014 CIP document and associated capital needs. The Plan was the first to be developed by GWA because previous efforts were focused on annual budgets or, in the case of GWA's 2005 Bond, a set of known projects. The "Five-Year Financial Plan" was developed using a top-down approach based on expected revenue, bonding capacity, and current and future liabilities. Although this process acknowledges the financial realities and establishes fiscal constraint, GWA unfortunately used the process to downwardly adjust many of the 2010–2014 project and program costs. Whether the actual estimated project costs were retained elsewhere within GWA was unclear. The application of this process might be understandable for program costs because these ongoing programs need to be aligned with fiscal constraints. The downward adjustment process for project costs and capital needs, however, causes several significant problems, including:

- Lowering of the actual capital needs, resulting in inaccurate needs and resource expectations
- Widening of the current discrepancies between GWA's preliminary engineering estimates and bids submitted by contractors

- Introduction of additional and unnecessary risk in the affected capital projects
- Unnecessarily limiting the utility of the 2010–2014 CIP report as a planning document.

This downward adjustment process was, in part, a significant reason that PG did not attempt to validate GWA's stated costs.

Additional analysis and recommendations for the financial planning process are provided in section 4 and further in Appendix 6.

## ***2.7 Recommendations for GWA CIP Program Improvements***

Throughout the assessment process it became increasingly clear that GWA's past CIP program lacked effective planning and discipline. The program and GWA capital needs were expressed in a series of unrelated and evolving documents; and capital cost estimates were highly variable and at times unreliable and non-reproducible. These observations are substantiated by the preceding sections of this report. GWA's General Manager, Chief Engineer, Chief Financial Officer, and other staff members have identified these shortcomings and have recently embarked on the development of an improved and systematic planning, design, and delivery process for capital projects. This ongoing development is a promising step in the right direction, and PG believes GWA's professional management should be provided the resources and support to allow them to move forward to develop and put forth an effective and disciplined CIP program.

This confidence in GWA's management is important because PG's initial inclination was to provide recommendations for improving each of the CIP Program documents or to recommend a preferred method or document for consolidation. However, acknowledging GWA's current efforts, PG instead finds it prudent to provide GWA with overall recommendations, leaving GWA to determine the preferred CIP Program and Master Plan approach.

1. PG recommends that GWA immediately develop an effective and disciplined CIP program. Without such a program, PG believes GWA could revert to reactionary project and program implementation, fail to maintain its critical assets, and be unable to successfully meet the demands of its citizens and certainly unable to meet the expected demands of the planned military buildup. PG believes this is one of the most important and pressing issue identified during this task.
2. PG recommends the development and implementation of a prevention-based O&M program. Veolia's efforts in the wastewater system can be used as the foundation for developing similar preventive maintenance programs for all operational divisions. These programs need to be developed and improved so as to significantly reduce the amount of corrective and emergency maintenance, which currently dominates the operational staff resources. PG believes this is one of the most important and pressing issue identified during this task.

Furthermore, PG recommends that GWA work with its divisions to define and articulate its true O&M needs. A systematic and reproducible process should be developed and implemented to facilitate this process. The process should include

methods and criteria for prioritization because it is likely that GWA's operational needs will exceed its available resources until capital, operation, and maintenance activities can be merged to create a sustainable utility. Ideally, the asset inventory and condition assessment provided in Chapter 7 of the WRMP can facilitate these activities.

3. GWA and CCU should support its professional management and staff as they strive to move forward with an effective and competent CIP program. The CIP Program requires an institutionalized planning process that includes robust capital, operational, and financial components. This institutionalized process needs to be understood and endorsed throughout GWA and the CCU. Specifically, PG recommends that the Chief Engineer be provided time and resources to more fully develop the planned CIP Program. During program development, GWA should seek frequent and candid input from stakeholders, including Guam EPA and U.S. EPA.
4. PG believes that ownership breeds implementation and that GWA would benefit greatly by actively engaging all levels of GWA in the development of the next iteration of CIP program. The program document(s) should articulate GWA's strategic visions, including both near- and long-term goals, and should provide a well-defined and institutionalized process for attaining these goals. The program documents should be concise and easy to read and understand, and they should primarily serve as a communication tool for GWA, its employees, and island stakeholders. Importantly, the program document(s) should be a useful planning tool for division staff from GWA Management, Finance, Engineering, Operations and Maintenance, and Production and Delivery.

GWA should include and then abide by an annual updating process that includes comprehensive, justifiable, and reproducible needs assessments; prioritization and funding sources; and capital resources and constraints.

5. PG recommends that GWA as an organization more fully endorse the value and importance of decision-making tools such as hydraulic models, GIS, and system characterizations and provide sufficient resources for their development and implementation. GWA could also reduce risk and improve project performance through improved cost estimation principles, enhanced contract language, and effective construction management and oversight. These tools and principles should be rapidly developed, institutionalized, and implemented, and they require organization-wide support.
6. PG recommends that GWA further evaluate the current inventory of planned wastewater system projects and programs and potentially reprioritize or modify the inventory of planned projects. The costs for those projects programmed for advancement should be reassessed, validated, and thoroughly documented to allow for future review. Likewise, a stepwise project identification and prioritization process is required in order to develop a specific list of projects to be accomplished as a component of the recurring wastewater and water system programs.
7. PG recommends that GWA prepare a revised and detailed Needs Assessment based on the Guam and CNMI Draft EIS/OEIS publicly available and any

additional information GWA has received regarding the NDWWTP, population projections, and water demands and delivery. As part of this effort, the Needs Assessment should include technically and financially sound, transparent, and substantiated needs in response to the military buildup. GWA should also explore options for identifying, or at least synchronizing, the Additional Needs within the context or confines of the CIP Program document. As stated above, past efforts to identify and articulate these needs externally with limited linkage to the greater CIP Program have led to confusion and potentially a misrepresentation of costs.

8. PG recommends that GWA adopt a standardized utility financial planning methodology that takes a bottom-up approach to assessing funding requirements. This process should begin by identifying capital and O&M needs and determining the appropriate user rate and financing approaches to fund those needs. Moreover, GWA should consider developing various scenarios and financial plans for the military buildup to ensure that it will be able to access funds quickly when plans are finalized and begin construction as soon as possible.

Additional recommendations for an improved CIP program and financial programs are provided in Appendixes 5, 6, and 7.

### **3.0 Assessment of GWA's Foundational Tools Necessary for Current and Future Decision-Making**

This section of the report provides PG's assessment of the foundational tools necessary for effective CIP decision-making. Note that PG does not believe the following list of tools is all-encompassing; rather, it is a base set of tools immediately needed to further improve GWA's CIP Program. Additional tools will likely be needed to create a fully sustainable utility. The following tools are assessed below:

- Fiscal planning cycle
- Water system hydraulic model
- Wastewater system hydraulic model
- GIS mapping
- Asset inventory and system characterization
- Project cost estimation
- Project identification and prioritization
- Procurement, contracting, cost containment, project management, and reporting
- Staffing.

Where appropriate, PG has provided recommendations for improving each tool. PG has also provided a "Road Map for Improved CIP Cost Estimation and Construction Cost Control" as Appendix 5.

### ***3.1 Fiscal Planning Cycle***

CIPs, Master Plans, and Financial Plans are intended to be living documents that should be updated and extended each year. At the same time, utilities update their budgets annually to fine-tune their financial revenues and expenditures even further. It was observed that GWA currently lacks a defined fiscal planning cycle whereby key decisions, plan updates, and approvals occur on defined dates or within defined time periods. This has resulted in ever-evolving planning documents and an inability to create and implement an effective financial plan. It appeared to PG that capital projects are inserted, removed, or reprioritized in an ad hoc fashion. This process can lead to selection and prioritization of lesser-need projects and potentially can subject the CIP Program to political or personal interests. The ramifications of this approach on financial planning can also be very serious, resulting in incomplete or partially funded projects, excessive bond reallocations, inaccurate financial assessments, and an inability to track expenditures against defined budgets.

Neither the “Five-year Financial Plan” nor the 2010–2014 CIP documents contained defined dates or periods for updating and assessment at the time of PG’s site visit. Although the General Manager, Chief Engineer, and Chief Financial Officer understood the necessity for a fiscal planning cycle and intended to include regular update periods within the respective documents, the fiscal planning cycle should be developed and endorsed at the CCU level. The CCU and GWA should develop and abide by a defined fiscal planning cycle that includes dates for data acquisition, needs compilation and budgeting, approval and implementation, and assessment. An example might include:

- June 30 – Needs acquisition from all GWA Divisions
- July 30 – Needs compilation and development of draft fiscal budget
- August 31 – Review and approval
- October 1 – Onset of new fiscal period
- March 1 – Mid-year assessment.

The above schedule is based on GWA’s defined fiscal year, October 1 through September 30.

### ***3.2 Water System Hydraulic Modeling***

GWA has emphasized the importance of a water distribution system model and GIS database in supporting its water system planning efforts. As part of the 2006 WRMP, a contractor developed a skeletonized model of the full GWA water distribution system. Separate versions of the model were created to address the current-day situation (2005), the current-day situation with projected changes in the distribution system corresponding to short-term CIP projects, and a 2025 situation incorporating longer-term CIP projects. However, some significant deficiencies in the model limit its usefulness. The most serious is that it has not been adequately calibrated, validated, or field-checked such that it can be confidently used to assess the present or future performance of the distribution system.

Furthermore, at this time the model is inadequate to serve the required purpose for the following reasons: (1) it does not run in extended-period simulation, and even successful use in steady-state is not dependable; (2) GWA personnel are not fully trained in the use

of the software; (3) assumptions and aspects of the model have not been fully evaluated; and (4) there has been virtually no validation of the model based on field data. A formal process for examining, calibrating, and field-validating the model is needed before it can be used with any confidence.

PG completed a detailed assessment of the water system model and its uses and has developed a suggested road map for its further development. The road map includes a suggested approach for examining and upgrading the modeling capability so that the model can be effectively used for GWA planning purposes. The “Water Hydraulic Road Map” is provided as Appendix 2.

### ***3.3 Wastewater System Hydraulic Modeling***

GWA has emphasized the importance of a sanitary sewer system model and GIS in supporting its wastewater system planning efforts. As part of the 2006 WRMP, a contractor developed a limited hydraulic model of the GWA sanitary sewer system. The model included existing sewers 10 inches in diameter and larger, which represent approximately 35 percent of the existing sanitary sewer system. The model addresses the population growth anticipated on Guam prior to the announced military buildup, and thus it does not include new sewers necessary to serve the buildup or the hydraulic impacts of the buildup on the existing sewers. In addition, there are some significant deficiencies in the current hydraulic model that significantly compromise its usefulness. The most serious deficiency in the current model is the choice of software used. The MWHSOft H2OMAP Sewer Pro software being used has a very basic steady-state hydraulic engine. This software is not sufficiently adept at modeling the sewer surcharging that routinely occurs in Guam’s sanitary sewers in most wet-weather events, and therefore the accuracy of flow rate estimates is limited. Second, the base sewer system input data used for the current model is incomplete and, in many cases, inaccurate. Third, the calibration of the model is suspect because the flow metering performed did not include measurement of SSO volumes. Therefore, it is not possible to perform a reliable “mass balance” of flows to ensure that the ultimate destination of these flows (e.g., WWTP or SSO) can be confirmed by actual field measurement.

PG completed a detailed assessment of the wastewater model and its uses and has developed a suggested road map for its further development. The road map includes a suggested approach for examining and upgrading the modeling capability so that the model can be effectively used for GWA planning purposes. The “Wastewater Hydraulic Road Map” is provided as Appendix 4.

### ***3.4 GIS Mapping***

The GWA GIS database was largely created in-house by GWA staff. The database currently houses asset information on both the potable water and wastewater system. During the creation of the database, it was GWA’s intent to use as-built drawings as a basis for its data; however, a review of available records showed a lack of record-keeping in previous years that had led to many as-built drawings not being located. To make up for this shortcoming, GWA used many design drawings, which it field-verified before entry into the GIS database. This created the base dataset to which GWA continually performs updates and improvements. The updates are currently based on two sources of information: (1) input from GWA operations and maintenance staff, which is field verified prior to entry, and (2) GIS data files, which are created by the leak

detection team on a weekly basis to show information acquired on recent leak detection and repair projects.

During the PG site visit, GWA was made aware that Guam EPA also maintains a GIS database of GWA assets created through previous collaboration between GWA operations staff and Guam EPA staff. GWA intends to acquire these data, field verify them, and include them in the GWA database if appropriate. A very cursory review of the two datasets by PG showed several assets in the Guam EPA database of which GWA was not aware.

The capabilities of GWA to handle incoming information in an appropriate manner are sound. GWA has acquired the necessary hardware and software, and the GWA staff in charge of maintaining the GIS database demonstrated to PG that they are very knowledgeable and capable.

There is a need, however, for additional staff resources in the GIS section of GWA. This person(s) could act as an intermediary between the various departments of GWA to improve the flow of information into the GIS database. A good example of this is the wealth of information that the various system operators possess, which is not yet represented in the GIS database. Another good example is the need for systematic and timely entry of wastewater collection system bottlenecks and defects that result in surcharging and SSOs. This information is currently compiled by Veolia and provided to the GIS department, but it is not entered in a timely fashion due to staff limitations. This person(s) could also coordinate and perform additional field verification of such data, especially the data produced by the leak-detection team. Yet another role for this person could be to act as an intermediary between the GIS database and the system modeling staff, providing input to modelers on recent modifications to the GIS and facilitating the general flow of information into the hydraulic models. It was readily evident that GWA's Engineering, Operations and Maintenance, and Production and Treatment divisions would benefit significantly from additional GIS resources.

### ***3.5 Asset Inventory and System Characterization***

PG characterizes GWA's current knowledge base regarding asset inventory and water and wastewater system characterization as "limited but improving." The process is limited because there appeared to be significant gaps in knowledge and documentation regarding water lines, booster pumps, chlorination systems, sewer lines, and appurtenances (e.g., manholes, forcemains). It was unclear to PG whether GWA's staff was aware of, and using, the asset inventory provided in Chapter 7 of the WRMP. In addition, GWA does not maintain a Computerized Management and Maintenance System (CMMS) for either system and until recently did not have a preventive maintenance program for the wastewater system. A preventive maintenance program, with an asset inventory as its basis, does not yet exist for the water system. PG recommends that GWA explore the use of the InfoCollect system identified in Chapter 7 of the WRMP for this purpose.

This is not to say GWA and Veolia personnel are not fully aware and knowledgeable of the location and condition of key assets. Rather, without the identification, mapping, and designation of recurring preventive maintenance, operations teams are predominantly occupied with corrective and emergency maintenance. GWA needs to establish a comprehensive asset inventory and develop and perform preventive maintenance so as to transition away from corrective and emergency maintenance.

GWA has been making progress in several areas, as best exemplified by the ongoing water reservoir assessments, leak-detection program, lift station and WWTP preventive maintenance programs, limited sewer line cleaning, acquisition and use of a closed-circuit TV (CCTV) truck for sewer line inspection, and GIS system. All of these activities are positive steps, and GWA is encouraged to support and expand these programs.

### 3.6 Project Cost Estimation

As stated previously in this report, GWA's cost estimation principles lack a defined and reproducible process, and rarely (if ever) is the basis of the cost well described or consistent. These deficiencies caused PG to forgo any attempt to validate stated costs.

For GWA these past cost estimation practices have led to wide variances between the Engineering Division's preliminary design estimates and bids received by contractors. In several cases they have led to the project's being divided into multiple phases spread over a series of years. An example is the Old Agat Wastewater Collection (I&I Reduction), which was split into two phases (05-01 and 09-03) once bids were received. For other projects these practices have, in part, led to large overruns (claims) and uncompleted projects.

Table 8 is a complete list of all projects funded through the 2005 GWA bond as provided by GWA during the site visit. It is a reduced transcription of a more complex table of the projects dated September 30, 2009. It includes the original approved project

**Table 8. Summary of GWA Projects Funded by GWA's 2005 Bond Issuance<sup>12</sup>**

2005 Bond Projects	Original Approved Project Cost	Adjusted Project Cost	Adjusted Cost as % of Original Approved Cost
Interim Disinfection Facilities	\$581,000	\$2,260,705	389.1
Northern District (Outfall)	\$4,700,000	\$11,284,131	240.1
Agana Outfall	\$5,030,000	\$10,493,032	208.6
Electrical Protection	\$1,000,000	\$1,541,775	154.2
"A" Well Transmission Line	\$2,413,000	\$3,251,038	134.7
Generation Equipment	\$700,000	\$880,000	125.7
Earth Tech Well Buyout	\$5,000,000	\$6,000,000	120.0
Vehicles	\$1,100,000	\$1,280,000	116.4
Automated Meter Reading	\$12,572,063	\$14,527,063	115.6
Agana Treatment Plant	\$10,475,000	\$11,122,828	106.2
Leak Detection/Line Replacement	\$8,200,000	\$8,585,699	104.7
Lift Station Upgrades	\$230,000	\$230,994	100.4
Chaot WW Pump Station/ Collection System	\$410,000	\$410,000	100.0
Mangilao Tank Repair	\$800,000	\$800,000	100.0
Water/Wastewater Master Plan	\$4,900,000	\$4,900,000	100.0
Land Survey	\$800,000	\$800,000	100.0
Old Agat Wastewater Collection (I&I	\$2,155,000	\$1,777,835	82.5

<sup>12</sup> Created by PG using data provided by GWA on November 11, 2009.

Reduction)			
Baza Gardens WWTP Upgrade	\$500,000	\$300,000	60.0
Santa Rita Springs - Booster Pump Rehab.	\$648,000	\$333,451	51.5
Collection Line Upgrades	\$200,000	\$100,000	50.0
Well Vulnerability Reduction	\$600,000	\$200,000	33.3
Laboratory Modernization	\$800,000	\$231,000	28.9
Booster Station Upgrades	\$390,000	\$100,000	25.6
Barrigada Tank Repair	\$3,000,000	\$500,000	16.7
Contingency	\$12,276,023	\$379,991	3.1
Storage Additions	\$950,000	\$0	0.0
Ugum Tank Replacement	\$2,500,000	\$0	0.0
Ugum WTP Refurbishment	-	\$6,300,000	x
GWUDI Study	-	\$634,032	x
Fena Bypass Transmission Line	-	\$224,500	x
Northern District WWTP Upgrade	-	\$200,000	x
Northern Treatment Plant	-	\$21,980	x

cost as well as the project cost after subsequent adjustments were made. Note that there are several projects that either were unforeseen or were not originally expected to fall under this bond allocation and therefore have no original approved project cost. GWA staff stated that approximately 10 bond reallocations have occurred since the 2005 bond was issued.

It is evident that a majority of the projects did not meet the original project cost expectations. Of the 26 projects that had costs originally approved under the bond, the costs of 11 were later adjusted upward by as much as 390 percent of the original cost and the costs of 5 were not adjusted or were only minimally adjusted. Eleven of the projects incurred costs less than expected by as much as 100 percent. Although the nature of each adjustment is unclear, the adjustments do reflect GWA's past inability to put forth accurate cost estimates and implement cost controls, as well as its need to do so in the future to maintain financial stability.

In summary, due to the cascading impact on projects, budgets, and financial planning, PG believes sound and disciplined cost estimation principles should be a paramount concern for GWA. The Chief Engineer should work aggressively to develop and institutionalize project and program cost estimation principles at the earliest opportunity. It is recommended that GWA develop these principles as a component of the re-costing necessary for the 2010–2014 CIP projects and the Additional Needs.

PG has prepared a brief road map for estimating costs and controlling construction costs, which includes some select recommendations for GWA's consideration. The "Road Map for Improved CIP Cost Estimation and Construction Cost Control" is provided as Appendix 5. It presents suggested procedures for preparing cost estimates. It also highlights the benefits of developing standardized cost-estimating procedures and the benefits of keeping cost estimates "living documents" throughout project planning, design, and construction. Appendix 5 also presents some suggestions on the use of cost

estimates for construction cost control. PG recommends that GWA develop broad staff knowledge in cost-estimating procedures. Toward that end, Appendix 5 highlights some sources of cost data and sources of cost-estimating training that would be of benefit to GWA. In addition to increasing overall staff knowledge of cost-estimating procedures, PG believes it would be to GWA's advantage to identify a specific cost-estimating team that would have overall responsibility for developing and maintaining all cost estimates and responsibility for monitoring cost expenditures during construction.

### ***3.7 Project Identification and Prioritization***

As previously stated, the 2010–2014 CIP report is the Engineering Division's attempt to identify and document all known ongoing and planned CIPs and is therefore considered the most complete representation of GWA's CIP Program. The projects included therein originate from a variety of sources, including the Stipulated Order, the 2006 WRMP, the Veolia CIP/PIP, and other undefined sources. The process by which CIPs were identified and initiated was at times unclear, and GWA does not have a written process for project identification and prioritization, with the exception of those projects identified in the Stipulated Order.

PG's review of the wastewater CIPs identified some projects that did not appear to merit their inclusion or prioritization in the 2010–2014 cycle (see Section 2.3). PG recommends that GWA develop a systematic and transparent process by which capital needs are identified, prioritized, and escalated to the CIP Program. This process should include the identification of sufficient reserve projects that can be accelerated into the planning process as additional resources become available or projects are slowed or re-programmed for unforeseen reasons. These "off-the-shelf" projects can reside within a 10-year CIP document and/or a Master Plan. Ideally this process can be intrinsically linked with GWA's much-needed strategic vision and goals.

Historically, CIPs were identified only by narrative titles that were subject to change, and their funding source and origin were often incomplete or missing. Cross-referencing projects from year to year (or document to document) was difficult for PG. PG did not evaluate internal financial tracking of past projects. Thankfully, the 2010-2014 CIP attempts to improve this process by including project numbers, reference documents, descriptions, justification, financing options and grants, staffing implications, and timelines. GWA should formally embrace this process to add transparency and traceability to all ongoing and planned CIPs.

### ***3.8 Contracting, Cost Containment, Project Management, and Reporting***

A key consideration is improvement in the contracting process to improve risk avoidance, cost containment, and project oversight. In most instances it appeared that the contracting process and the determination of standard and project-specific conditions had been left to the senior engineers. Although PG did not review past contracts in detail, discussions with GWA engineers indicated that much, if not all, of the project risk has been shifted from the contractor to GWA. This has resulted in frequent and large value claims on several projects. To remedy this problem, the Chief Engineer stated that this process would be transitioned to the Engineering Support Section to ensure consistency and relieve the burden from the engineers. The primary person in that section was off-island during PG's visit, and thus these topics were not discussed in great detail. Moreover, Veolia had recently been hired to develop and administer contracts for the Moratorium Project, and both GWA and Veolia representatives said that

this was the first attempt at shifting risk to contractors and away from GWA. PG concurs that this will benefit the program and the accountability of future contracts and encourages GWA to move forward with these improvements.

It was also clear that more defined roles, expectations, and reporting are needed for construction management contractors and personnel so as to improve project performance and delivery. GWA has used many different approaches for construction management, including in-house personnel and private contractors, and there was no preferred or required approach. Expectations and report frequencies and formats for the construction management personnel were not uniformly defined, and therefore the utility of these persons varied greatly from project to project. GWA should recognize these persons as a primary mechanism for cost containment and project adequacy and should therefore establish formal procedures for their procurement, responsibilities, and reporting. Furthermore, clear expectations for performance should be established, and contractors found to be not fulfilling these expectations should be replaced. PG provides additional recommendations for effective construction management in Appendixes 4 and 5.

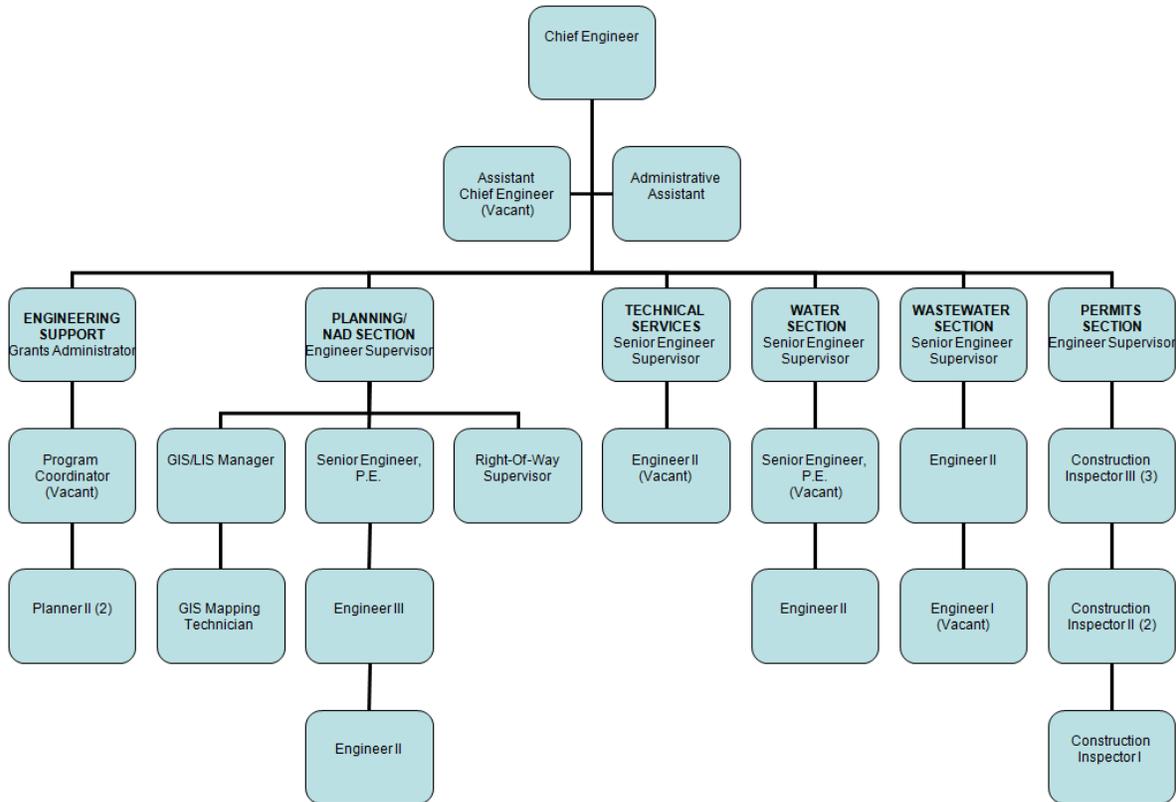
Appendix 5 also presents PG's recommendations for improving the "construction documents" that GWA prepares for its projects. Construction documents are the information that GWA issues to contractors (and bidders) for projects. The construction document package typically contains detailed drawings of the work desired, technical specifications covering the various work components and installation requirements, and construction administration procedures. PG suggests that GWA consider substituting the Standard Terms & Conditions and other supporting documents developed by the EJCDC for its current terms and conditions. PG believes that the Engineers Joint Construction Documents Committee (EJCDC) documents would place GWA in a significantly stronger position for administering construction contracts. Toward that goal, PG also recommends that GWA particularly strengthen the language in its technical specifications regarding testing the contractor's work as it is being installed and its specifications regarding performance measurement and payment for the work. **It is imperative for the future success of civil construction on Guam that no construction be paid for, either partially or fully, until that work has passed 100 percent of the relevant installation and performance testing requirements.**

Specifically, GWA needs to convince contractors that non-conforming construction work will no longer be tolerated under any circumstances. PG recognizes that this was historically problematic to GWA due to the limited number of contractors and specialized services available on the island. However, PG believes the forthcoming military buildup and related infrastructure work will significantly increase the number and technical capabilities of bidders available to GWA.

### ***3.9 GWA Staffing***

The GWA Engineering Department is divided into six separate sections, all overseen by the Chief Engineer and the Assistant Chief Engineer (position currently vacant). An organizational chart of GWA engineering staff is provided as Figure 2. The six sections are described below.

1. **Planning & New Area Development Section.** The System Planning and New Area Development Section of the Engineering Department deals with the long-term needs of GWA and the review of development plans within the GWA service area. This



department coordinates which CIPs are in line with the long-term goals of the organization and creates the Capital Improvement Plan, as well as any other project planning documents required for GWA to function properly. The new area development area of this section is also responsible for the review of plans submitted to GWA by developers. There are currently seven staff positions in this section (including GIS support).

2. **Mapping and Records (GIS) Section.** This section is embedded within the Planning and New Area Development Section and is responsible for creating and maintaining the GIS databases of system assets, and creating maps to aid in the planning process. There are currently two staff positions in the GIS subsection.
3. **Water Section.** This section provides engineering services from planning through construction for areas of GWA related to potable water supply, treatment, and distribution. GWA currently has three staff positions under this section, one of which is vacant.
4. **Wastewater Section.** This section provides engineering services from planning through construction for areas of GWA related to wastewater collection, conveyance, treatment, and disposal. GWA currently has three staff positions under this section, one of which is vacant.

Figure 2. GWA Engineering Staff as Created by GWA October 2009.

5. **Permits Section.** This section performs reviews of single-family water and wastewater connection permits, performs inspections of new connections, and provides field engineering and utility location services for private development construction projects. This section currently has four staff positions.
6. **Technical Services.** This section provides technical engineering services to other sections and deals with system-wide projects such as the SCADA system. This section currently has two staff positions, one of which is vacant.
7. **Engineering Support.** This section provides staff to support engineering efforts. It is responsible for procuring grant funding for capital projects. There are three staff positions in this section, one of which is vacant.

GWA's is chronically understaffed and has difficulty attracting and retaining qualified staff. At the time of PG's visit, there were a total of five vacancies in the GWA Engineering staff. GWA noted that it has been trying to fill the positions; however, the caliber of applicant that the current level of compensation attracts is below the minimum qualifications that GWA desires and the Stipulated Order requires. The vacant positions are as follows:

- Assistant Chief Engineer
- Senior Engineer, P.E. (Water)
- Engineer II (Technical Services)
- Engineer I (Wastewater)
- Program Coordinator (Engineering Support)

It is imperative that GWA fill these vacancies as soon as possible to allow current employees to more effectively fulfill the roles to which they have been assigned. In addition, it is important to note that existing staff are consumed with keeping the utilities operating from day to day and it appeared unlikely that they will have the time or resources to adequately plan for the military buildup, even with additional personnel. PG believes the engineering, design, construction oversight, and contract management associated with GWA's planned CIP and military buildup will require extensive technical and administrative resources not readily available to GWA. GWA itself has identified this need and noted in the 2009 Needs Assessment that it plans to hire contractors to provide engineering services.

Therefore, in addition to hiring staff, PG recommends that GWA obtain independent engineering support to work directly with GWA to (1) identify and substantiate additional infrastructure needs associated with the military buildup; (2) establish a schedule identifying the sequence of additional needs planning, design, and construction activities; and (3) develop criteria and subsequently promote an apportionment of the associated costs to GWA and the military. This process would start as soon as possible and extend throughout the military buildup planning process.

GWA has embarked on an internal "management analysis" using an external vendor. At the time of the PG site visit, Phase I of the project was said to be completed and Phase II was ongoing. The results of the analysis and any resulting action plan should be assessed for conformance with this report.

## **4.0 Assessment of GWA's Financial Condition to Operate and Maintain Current and Proposed Infrastructure**

PG contracted with Northbridge to assess GWA's financial condition. Northbridge completed its preliminary assessment and prepared a technical memorandum documenting its findings. The technical memorandum is provided as Appendix 6 to this report. A summary of the assessment, which includes the goals of the assessment, key findings, and next steps, is provided below.

### **4.1 Assessment Goals**

The Technical Memorandum is a preliminary review of GWA's financial plans and processes. Because the 2010–2014 CIP and 2009 Five-Year Financial Plan contain the most up-to-date information on GWA's direction, the memorandum primarily evaluates those documents. Information from the 2006 WRMP is incorporated as needed. It also compares the GWA's financial planning practices with industry-standard processes. In addition, the memo reviews the primary assumptions in the current Financial Plan and discusses potential problems and inconsistencies. Finally, it assesses GWA's ability to finance the current CIP and use financial modeling to test various assumptions. Because much of the data available from GWA is incomplete or will be refined in the next several months, Northbridge anticipates that a more extensive review of the financial projections and assumptions will be possible in the near future.

Since the 2006 WRMP was released, GWA has brought new management on board, including the General Manager, Chief Financial Officer, and Chief Engineer. They have been in the process of reevaluating the priority projects and associated revenue requirements. This has resulted in an updated 2010–2014 CIP as well as a 2009 Five-Year Financial Plan.

While neither document is viewed as complete and up-to-date, they represent significant steps forward for GWA. According to GWA staff, the 2010–2014 CIP development process brought engineering and financial staff together for the first time. This allowed GWA to identify in the CIP how it anticipates funding the projects, be it through specific-year bond funds, grants, or other sources. In addition, the Five-Year Financial Plan is a first for GWA and was used during the evaluation and approval of rate increases for the next four years. As a result, GWA will not have to petition the Public Utilities Commission (PUC) every year for new rates. This preapproval of rate increases provides GWA management with greater confidence in its ability to fund projects, as well as valuable information for current and future bondholders. These are steps in the right direction and GWA, the PUC, and the CCU are encouraged to continue moving down this path.

### **4.2 Summary of Findings**

The full technical memorandum discusses a number of findings related to GWA's financial planning practices. The findings are summarized below:

- It is critical that a utility with the size and complexity of GWA adopt a robust capital investment and financial planning methodology. GWA should use a typical utility financial planning methodology, which takes a bottom-up approach to assessing revenue and market financing needs. This process begins by

identifying capital and O&M needs and determining the appropriate user rate and financing approaches to fund those needs.

- To minimize uncollected revenues and reduce costs, GWA should focus on collecting late payments, curing delinquencies, and minimizing unaccounted-for water losses.
- Planning for contingencies could help GWA manage unexpected events, such as non-functioning water meters and higher-than-anticipated power costs.
- Avoiding bond reallocations when possible by obtaining better cost estimates could help prevent modifications or audits that impact bondholder confidence.
- In developing its financial plans and projections, GWA should ensure that its assumptions are realistic and appropriate, particularly for water and wastewater system revenues, payments on bonds and debt service coverage ratios, and system expansion costs.
- GWA should consider developing various scenarios and financial plans for the military buildup to ensure that it will be able to access funds more quickly when plans are finalized and begin construction as soon as possible.
- GWA is encouraged to plan for other potential high-cost contingencies, such as implementation of secondary wastewater treatment, to avoid financial obstacles.

Finally, different user rate levels can have a dramatic impact on the levels of capital investments that can be funded by the utility. From an affordability standpoint, many entities consider the total average user charges as a percent of median household income (MHI). Different user fee levels can significantly alter a utility's ability to finance projects. For example, increasing user rates from 2 percent of MHI to 3 percent can increase affordable market financing levels roughly twelve-fold, based on rough calculations conducted for this report. GWA should consider what level of user fees is affordable and acceptable to Guam residents and businesses.

### **4.3 Next Steps**

GWA's current management is on the right track toward improving financial management. They are encouraged to continue working on enhancing GWA's financial management capabilities and incorporating the CIP process into financial management. As the technical memorandum notes, there are a few areas where GWA is encouraged to take another look. The first is to build up financial plans from the bottom up, using a process more similar to the industry standard. This will help ensure that the highest-priority capital investments are tackled early and that sufficient operations and maintenance resources are allocated so GWA can properly operate and maintain the existing facilities, resulting in the longest useful life of the existing infrastructure. Improving the accuracy of the costs associated with capital investments and O&M is essential to this process. At the same time, it is important that the facility ensure that it can afford the investments and that user rates remain reasonable. As a result, developing CIPs, Financial Plans, and budgets is an activity best conducted with close cooperation between the CFO and Chief Engineer. This is a continual process, with

CIPs and Financial Plans being updated at least annually. GWA has taken the important first steps in this process and is encouraged to continue along this path.

The military buildup and potential changes in treatment requirements are important high-cost areas for which GWA does not appear to be planning adequately. Developing contingency financial strategies will help GWA plan through the potential impacts and put it in a better position to obtain outside funding quickly if necessary.

GWA's key goals are to provide safe and reliable service to its customers, reduce water loss, meet and maintain compliance with regulatory permits, and increase O&M funding. GWA has improved the reliability of its water distribution system and is making progress in its leak-detection program. Reportedly more than 11,000 leaks were repaired in 2007 alone.<sup>13</sup> Efforts are under way to repair faulty meters, which should improve the accuracy of invoices and bill collection. In late 2009, however, \$16.8 million in receivables were 61 days or older. Reducing this delinquency is fundamental to funding ongoing O&M and to securing lower-cost financing for necessary capital improvement needs. A valuable study could be to look at the financial impact of improved water accountability and receivables collection and to forecast the extent to which rate hikes might be avoided (or diverted to other important investments) as a result.

A future study could also provide a more comprehensive view of what GWA ratepayers can afford and how that integrates with the needs on the island. Where shortfalls exist, the follow-up study could look at other funding opportunities, such as grants and low-interest loans, that might allow GWA and its ratepayers to better afford the large capital investments required to bring the facilities up to standard and ensure high-quality water and sewer services for all of Guam's residents.

Because GWA has a bond rating of BB, its interest rates are high. Improvements in the operation and management of the utility over time will likely result in an improved bond rating. For the near term, however, alternative financing mechanisms should be considered. Possible strategies are outlined in a memorandum to EPA from PG's subcontractor, Northbridge Environmental, which is attached to this report as Appendix 7. They include:

- Cost sharing with federal agencies or other partners
- Bond bank
- Infrastructure bank
- Federal credit assistance
- Revolving loan fund
- Federal guarantee
- Build America bonds
- Government-sponsored enterprise
- Development bank
- Private equity.

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<sup>13</sup> Joint Guam Program Office, *Draft Environmental Impact Statement/Overseas Environmental Impact Statement, Guam and CNMI Military Relocation*, Vol. 6, Chap. 3, p. 3-12 (November 20, 2009).

## **5.0 Identification of Overarching Issues and Recommendations**

PG identified the following issues that are likely to affect the island's water resources and delivery of water and wastewater services. The list is not intended to be exhaustive; it includes some of the most pressing issues that will require the attention of GWA and other stakeholders.

### ***5.1 Guam Military Buildup and Additional Needs Assessment***

Overarching issues related to the military buildup and additional needs assessment are summarized in this section.

#### **5.1.1 WWTP and Outfall Improvements**

It appears that the Department of Defense (DoD) plans to discharge to the Northern District WWTP, at least during the early phases of the military buildup, since DoD identifies only one "Interim Alternative" (also referred to as the "Preferred Alternative") in the early release draft environmental impact statement (erDEIS; Vol. 6, p. 5-19). The Interim Alternative involves coordinating with GWA to restore the plant to its 12-MGD design capacity, make necessary improvements to bring it into compliance with its NPDES permit, and install a diffuser at the ocean outfall. It is noted that the cumulative influent to the plant is expected to increase to 12.31 MGD in 2015 (DEIS, Vol. 7, Table 2.3-6). The current daily flow through the plant is 10.6 MGD (EPA Fact Sheet, September 30, 2009).

On September 30, 2009, EPA denied GWA's request for a Clean Water Act section 301(h) variance for the Northern District WWTP. This action likely will require additional upgrades to the plant to bring it to secondary treatment levels, as well as possible additional modifications to the outfall and diffuser beyond what was described in the DEIS.

GWA and NavFac Pacific need to begin work now to assess the near-term and long term flows, prepare designs, and provide cost estimates for the necessary upgrades to the WWTP, outfall, and diffuser. GWA should use this information to update the Needs Assessment.

#### **5.1.2 Ensuring Adequate Sewer Conveyance Capacity**

GWA should actively solicit DoD for finalized phased (year-by-year) population increase projections, including all temporary construction workers, and the projected geographic distribution. Ideally, the population distribution would be in the form of an overlay to existing Guam planning maps. Concurrently, GWA should work with the Guam EPA to review the overlays and assess whether there are adequate water and wastewater utilities, and where additional expansions will be required. Ensuring adequate capacity in the sewer conveyance systems will be important because SSOs are a significant problem and a potential threat to the Northern Guam Lens Aquifer (NGLA) (see Section 5.5 below). In no case should temporary housing be permitted in unsewered areas. GWA will need as much advance planning as possible to determine needs for new and expanded sewers and to develop timelines and costs for their installation because the greatest demand on its systems will occur during the construction phase of the project.

### 5.1.3 Connectivity with AAFB Water System

In separate meetings with GWA and NavFac Pacific, PG was informed of both parties' interest in one or more direct connections between Andersen Air Force Base's and GWA's water systems as a means to meet temporary water demands during construction of the temporary worker housing. It was believed these connections could be established more rapidly than GWA well production and provide water while GWA and/or private development established the 16 water wells proposed by GWA. GWA and NavFac Pacific should aggressively engage in more direct discussions regarding this or an alternative plan, identify possible connection points and all possible ramifications, and then prepare detailed designs and cost estimates. PG also recommends including Guam EPA personnel in these discussions.

### 5.1.4 GWUDI

The NGLA aquifer is prone to contamination from bacteria and chemicals due to the highly permeable nature of the karst geology. Contamination is widespread, but not all wells are contaminated. Therefore, the findings of the GWUDI study are uncertain. However, depending on the results, additional treatment for some or all of the raw water used by GWA might be required. This could necessitate significant centralization of treatment and construction of extensive raw water transmission facilities. Though there is still significant uncertainty associated with GWUDI determination, it is imperative for GWA to start developing long-term plans as a contingency.

### 5.1.5 Unsewered Areas

Approximately 40 percent of housing units on Guam are served by septic systems, including a high percentage in North Guam in areas that are not served by sanitary sewers.<sup>14</sup> Septic systems in North Guam are a significant source of bacterial contamination of the aquifer. GWA engineering staff stated that the unsewered areas, along with the closest sewer line, had recently been mapped within the GIS. In addition, a law had recently been passed that requires users within a set distance of any existing sewer to connect within a preset time period.<sup>15</sup> GWA had also established a connection assistance program with an initial balance of \$75,000. The program's funds were intended to be used to partially offset the connection costs, which had increased recently due to the establishment of the System Development Charges. At the time of the PG site visit, GWA could not definitively state whether any users had connected to the sewer as a result of the new law, but GWA did know that the \$75,000 had not been accessed and remained fully intact.

GWA should further evaluate this issue, begin assessing the areas that present the highest risk to the NGLA, and identify what efforts may be required to more effectively move households from septic systems to sewers. For example, efforts should be expended to assess the feasibility of sewerage prioritized areas, increasing financial incentives, or a combination of both. This issue is particularly important due to pending GWUDI determinations and the planned increase in housing and populations overlaying the NGLA.

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<sup>14</sup> DEIS, Vol. 6, Chap. 3, p. 31.

<sup>15</sup> PG did not obtain a copy of the law and therefore does not have complete information on the distance and/or time requirements.

## ***5.2 GWA Preparedness***

To date GWA has taken a largely passive role in planning for the development and resource needs associated with the anticipated military buildup. Most of its planning documents lack acknowledgement of the buildup; others lack substantiation of needs and cost realism. In some cases, this is because GWA has been waiting for the military to provide information or has been accessing publicly available information as it becomes available. GWA should take a more proactive role in engaging the military on the buildup's scheduled needs and impacts on GWA's systems and the NGLA. Rather than waiting for DoD to provide information, GWA should actively solicit it (in the form of written requests) to provide as much lead time as possible for planning. In this way, GWA can develop a phased strategy for meeting the military's needs and protecting the NGLA. In addition, GWA will be better positioned to evaluate the true costs and to substantiate requests for fair compensation.

PG was encouraged that GWA has included resource requests for additional plan review staff in the Additional Needs assessment and the 2010–2014 CIP. This is clearly a step in the right direction. GWA should continue and expand on that approach by assessing its entire operation and determining where, and at what point, additional operations, maintenance, and other (e.g., legal, procurement, customer service) needs exist. The fact that these additional needs might not materialize for many years is positive and allows sufficient time for GWA to plan accordingly and secure funding.

## ***5.3 Construction Oversight and Mitigating Storm Water Impacts***

Under all scenarios of the anticipated military buildup, it is clear that a significant and unprecedented amount of infrastructure construction will occur throughout the island. The construction activity and resulting storm water runoff pose a risk of contamination to the NGLA. GWA has a vested interest in protecting the aquifer and island water resources. PG is concerned that GWA might not have the staff resources needed to effectively track, inspect, and ensure compliance with local and federal laws for their projects. Furthermore, it is imperative that a coordinated plan be established and put into place to prepare for the expected construction boom. For example, a multi-divisional GWA team could combine resources (expertise and staffing) in a coordinated strategy for regulating and inspecting grading activities and storm water control, and for monitoring the impacts.

GWA should also consider post-construction storm water controls and impacts. Construction activities might increase the amount of impervious area, which could increase the amount and intensity of pollutant discharges in the form of urban runoff. Imperviousness could also accelerate the rate and volume of storm water discharges, which could cause hydro-modification and habitat degradation in receiving waters. GWA should seek active participation in the development of a comprehensive and island-wide approach to post-construction storm water controls, including any required monitoring.

## ***5.4 Island-Wide Fats, Oils, and Grease Program***

The discharge of fats, oils, and grease to the sanitary sewer is causing significant, and unnecessary, problems for GWA. These problems include (1) grease accumulations restricting sewer capacities, resulting in surcharging; (2) complete blockages, resulting in SSOs and surface water contamination; (3) increased maintenance needs and costs at pump stations, within the sewer, and at WWTPs; and (4) impacts on WWTP

performance. These problems are evident across the entire island, and Veolia representatives stated that grease was the cause for more than 50 percent of all SSOs. Additionally, one or more of the sludge drying beds at the Agat-Santa Rita WWTP are being used to “store and dry” grease waste until it can be hauled to the landfill. It unclear to PG whether the accumulated grease is actually removed from this location.

It was explained to PG that Guam EPA has primary authority and responsibility for regulating grease discharges. However, both Veolia and GWA representatives stated that GWA’s sewer use ordinance contains the necessary language to prohibit the introduction of grease into the sewer. Veolia has identified grease as a major concern and has previously requested authorization for hiring and deployment of a grease inspector. In its request, Veolia estimated the payback for this hire to be less than three months (possibly even one month), which is attributed to reduced time and expense responding to blockages and maintaining equipment. The request was denied and the position remains unfilled.

PG believes that grease control is “low-hanging fruit” for both GWA and Guam EPA and encourages an aggressive, coordinated campaign by both agencies to combat this problem. Many examples of effective programs exist; they can be used as a template and to substantiate the cost savings. An effective program on Guam will need to include public awareness campaigns, effective oversight of grease-generating establishments, and increased used of grease interceptors.

In addition, the island is in need of a comprehensive plan for handling grease, which should include one or more centralized grease disposal and/or recycling facilities. There are many examples of successful grease recovery, recycling, and biofuel facilities on the U.S. mainland that again could serve as templates for a similar program on Guam. The culinary preferences of Guam and the high density of restaurants make this even more imperative.

PG strongly recommends that both GWA and Guam EPA rapidly address this very apparent need.

### ***5.5 Industrial Pretreatment Program***

GWA does not currently operate an industrial pretreatment program to control the discharge of conventional and non-conventional pollutants or other prohibited wastes to the sewer system and WWTPs. Industrial discharge characteristics can include high temperatures, excessive solids, toxics, slug loads of pollutants, and corrosive conditions, among others. These discharges can impact both the collection system and WWTP. For example, with respect to primary treatment WWTPs, they can result in direct pass-through of pollutants to the receiving waters and can affect plant performance. For secondary WWTPs, the discharges can adversely affect the biological systems and reduce treatment efficiency or even destroy the biomass. The discharges also can lead to severe and unpredicted operational swings. It is also possible that, due to the long-standing history of SSOs on the island, industrial discharges could affect groundwater.

PG did not attempt to evaluate the presence of industrial users on the island or evaluate effluent quality from the WWTPs to establish a need for an approved industrial pretreatment program. The issue was brought to PG’s attention during a meeting with NavFac Pacific due to NavFac Pacific’s concerns about possible upgrades to the

Northern District WWTP. NavFac Pacific expressed concerns that future NPDES permits and a possible upgrade to secondary treatment could impose additional and more restrictive effluent and Whole Effluent Toxicity (WET) limitations on future discharges. PG concurs with this assessment. NavFac Pacific further stated that it intends to create a separate influent sampling station on its influent line to the WWTP, which would provide the ability to monitor the characteristics of the wastewater prior to its commingling with domestic sources.

PG believes GWA, Guam EPA, and U.S. EPA should examine the potential ramifications and benefits of establishing an industrial pretreatment program on the island. PG bases this statement on the anticipated population increases, largely centralized population centers served by the Northern District and Agana WWTPs, pending NPDES permit reissuances, and possible upgrades to secondary treatment.

## **Guam Waterworks Authority Master Planning Technical Assessment**

### **Appendix 4**

#### **Road Map for Wastewater Model and Conveyance System Improvement**

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## TECHNICAL MEMORANDUM



TO: U.S. EPA Region 9, Water Division

FROM: PG Environmental, LLC

DATE: January 29, 2010

SUBJECT: **APPENDIX 4 - Road Map for Wastewater Model and Conveyance System Improvement**  
EPA Contract EP-09-0801, Task Order 16, Subtask 4

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### INTRODUCTION

GWA has emphasized the importance of a sanitary sewer system model and geographic information system (GIS) in supporting its wastewater system planning efforts. As part of the 2006 Water Resources Master Plan (WRMP), a contractor to GWA developed a limited hydraulic model of the GWA sanitary sewer system. The model includes existing sewers 10 inches in diameter and larger, which represent approximately 35 percent of the existing sanitary sewer system. The model addresses the population growth anticipated on Guam before the announced military buildup; therefore, it does not include the new sewers needed to serve the buildup or the hydraulic impacts of that buildup on the existing sewers. In addition, there are some significant deficiencies in the current hydraulic model that significantly compromise its usefulness.

The most serious deficiency in the current model is the choice of the software being used. The MWHSoft H20MAP Sewer Pro software has a very basic steady-state hydraulic engine. This software is not sufficiently adept at modeling the sewer surcharging that routinely occurs in Guam's sanitary sewers during most wet-weather events, and consequently the accuracy of the flow rate estimates is limited. Second, the base sewer system input data used for the current model are incomplete and, in many cases, inaccurate. Third, the calibration of the model is suspect because the flow metering that was performed did not include measurement of sanitary sewer overflow (SSO) volumes. Therefore, it is not possible to perform a reliable "mass balance" of flows to determine whether the ultimate destination of the flows was a wastewater treatment plant (WWTP) or an SSO. The following detailed assessment and road map for the development and use of a water distribution system model presents a recommended plan for upgrading and using a model for future GWA planning needs.

### 1.0 ROAD MAP FOR WASTEWATER MODEL AND CONVEYANCE SYSTEM IMPROVEMENT

GWA has identified the development of a computerized hydraulic model as a key step in all future analysis of the wastewater conveyance system and assessment of future projects. At this time, the model of the sanitary sewer system developed as part of the 2007 Water Resources Master Plan is inadequate to serve the required purpose for the following reasons: (1) it does not accurately model sewer surcharge conditions; (2) only

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35 percent of the existing sewers are represented, and portions of that system are inaccurately modeled; (3) the flow data collected for model calibration are inaccurate because they do not include SSO volumes; (4) because of its steady-state hydraulic engine, the current software cannot accurately model some of the complex system configurations present in the sanitary sewer system; and (5) GWA personnel are not fully trained in use of the software. A suggested approach for examining and upgrading the modeling capability is presented in this section. A formal process for examining, calibrating, and field-validating the new hydraulic model is needed before the model can be used with any confidence.

1. **Replace the current MWHSOft H2OMAP Sewer Pro Software.** The first step in developing a reliable hydraulic model of Guam's sanitary sewers is to replace the current H2OMAP Sewer Pro software with software that has a more powerful hydraulic engine capable of analyzing non-steady-state hydraulic conditions, particularly sewers that surcharge frequently. The most widely used software for such analyses is the EPA Storm Water Management Model (SWMM). The SWMM hydraulic engine is available in a variety of public-domain and proprietary software packages.

The key in selecting any particular SWMM software package is most likely the ease with which the input data already developed for the current H2OMAP Sewer Pro model can be transferred to the new model. EPA's free SWMM software package has been upgraded recently to greatly improve its user interface (a past complaint regarding this software). It is not known, however, what challenges will be encountered in trying to upload GWA's current sewer system input data to the SWMM software. Other proprietary SWMM-based software packages are available in the marketplace. They are based on the input of GIS databases that might be more convenient and ultimately more economical to use, despite their initial purchase costs. Typically, such models can cost \$5,000 to \$20,000 plus annual upgrade/support fees. However, this cost can usually be quickly recouped in savings on the labor otherwise expended to re-input sewer system data because of GIS incompatibility.

The most easily adaptable SWMM model for use in Guam is likely to be MWHSOft's H2OMAP-SWMM software. This package combines the H2OMAP GIS input interface, with which GWA is already familiar, and the more powerful SWMM hydraulic engine. Also, since GWA already has MWHSOft software, there might be a reduced cost to upgrade the existing software rather than purchase an entirely new software package from a different vendor.

Regardless of the particular modeling software selected, the transferability of the existing input data should be confirmed before any funds are spent. Furthermore, GWA's staff will require significant additional training in the use of any sewer-modeling software, including the current package. Therefore, now is the best time to make a software changeover, so that the value and efficiency of that training are maximized.

2. **Use a team-based approach.** Though the lead modeler for GWA is the key person in everyday use of the models, the modeling process needs to be treated as a team process. Members of the team should include GWA staff representing

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collection, conveyance and treatment, GIS, engineering, planning, and the like and possibly Guam EPA. They should meet regularly and both provide input to the modeling process and play a role in oversight and review.

3. **Verify the accuracy of the hydraulic model input data.** The accuracy of the pipe network included in the hydraulic model needs to be confirmed. From a hydraulic modeling perspective, one of the virtues of Guam's sanitary sewer system is that it is actually several small, independent sewer networks, with little if any interaction among them. This greatly speeds model development and calibration. It also reduces the size and cost of the modeling software package required. It is PG's understanding that as GWA needs to make decisions about sewer improvements in a particular network, it is re-validating all the sewer input data for that network through visual inspections and measurements in the field. This is an excellent approach to ensuring the most accurate model, and GWA is encouraged to complete this process for all the individual sewer networks as soon as possible.
4. **Expand the pipe network represented in the sanitary sewer system hydraulic model.** The hydraulic model is reported to include all sanitary sewers 10 inches in diameter and larger. Based on data in the 2006 WRMP, this would be approximately 35 percent of the existing sewer system. Although it is rarely cost-efficient or technically necessary to model 100 percent of the pipes in a sanitary sewer system, it is important that all "significant pipes," such as those pipes where SSOs are occurring, be modeled. It is recommended that the Guam sanitary sewer models be extended at least two links (1,000 to 2,000 feet) upstream of any recurring SSO location regardless of sewer diameter. It is also important to include at least skeletal sanitary sewer networks to represent the sewer system growth that will occur because of the military buildup.
5. **Extend the wastewater facilities planning period and include the anticipated military buildup.** Currently, GWA seems to be using extremely short planning periods for major sewer projects, as evidenced by the central Sewer Limitations (Moratorium) Project. This project is based on estimated growth only to 2025 and does not include the potential hydraulic impacts of military buildup. Although the facilities proposed include some reserve capacity for future growth, there is no link between the sizing of the facilities and actual future needs. The 2007 WRMP is apparently based on estimated 20- to 30-year population growth, but it also does not include the demands of the military buildup. Typically, sanitary sewer conveyance facilities are based on 40- to 50-year planning periods. The use of shorter planning periods tends to disproportionately favor lower-capital-cost/ higher-O&M-cost solutions, such as pump stations and forcemains, over more reliable and cost-efficient gravity sewers. It is recommended that all future wastewater conveyance system planning be based on 50-year needs and that the full hydraulic impacts of both the military buildup and related non-military population growth be considered in developing future design flow rates.
6. **Re-calibrate the hydraulic model using a "mass balance" approach and rely only on smaller rainfall events for calibration data.** The calibration of the hydraulic model should also address the "water in equals water out" balance

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equation, as well as matching flow patterns. Toward that end, it will likely be necessary to do additional flow metering that includes *accurate* measurement of any SSOs that occur during the metering period. Also, considering the intensity of rain on Guam, GWA should consider using a ratio of one rain gauge to one flow meter, at least in the initial calibration processes for each sewer network. Target “water in / water out” ratios should demonstrate that at least 99 percent of incoming flow is accounted for as discharges to the WWTPs or as SSOs. Considering the apparent high stormwater inflow rates into Guam’s sanitary sewers, GWA should be using only smaller rainfall events to calibrate sanitary sewer models. The 2007 WRMP reportedly used a “typhoon” rainfall event for predicting wet-weather flows. The MWHSOft H2OMAP Sewer Pro software is not capable of analyzing the surcharging and SSOs that such an event would likely cause throughout the existing sanitary sewers. Thus, this software tends to greatly underestimate peak wet-weather flows and therefore underestimate the sizes of the new facilities required to transport those flows. On the basis of the existing sewer conditions, it is recommended that only rains of one-half inch or less be used for calibration of the hydraulic model. It is recognized that, considering the typical heavy rainfall on Guam, this might not be possible. In no case, however, should rainfall greater than one inch be used; therefore, flow metering periods might need to be extended until such rainfalls occur.

7. **Use calibrated sewer model output information to plan sewer system investigation activities and improvement programs.** Once an accurate hydraulic model of the existing sewer system becomes available, this model can be used to prioritize sewer system investigation and repair efforts.
8. **Improve the inspection of the construction of new sewers and other wastewater conveyance facilities.** It has been reported that in at least one case a new sewer was constructed in a key location in GWA’s sanitary sewer system that cannot be used because of high levels of infiltration into that new sewer. The existing hydraulic modeling shows that SSOs currently occurring in the area that would have been tributary to this sewer could be reduced if the sewer could function as it was designed. All pipe materials being manufactured today are capable of being installed to yield extremely low levels of infiltration without requiring unusual levels of construction skill. Infiltration should not exceed 100 gallons per day per inch-mile of pipe diameter in any new sewer. Failure of a pipe to meet infiltration standards can be traced to two primary causes—lack of training of contractor personnel in proper construction procedures and lack of care by the contractor in enforcing those procedures. These problems can be corrected by pre-construction training, proper field inspection during construction, and appropriate contractor payment procedures.
9. **Contractor training.** Pipe manufacturers should be required to provide training to key contractor personnel—site superintendent, head pipe layer, and others as appropriate—in the proper procedures for installing the pipe. (It is also recommended that GWA’s inspectors attend this training.) The pipe manufacturer should provide a certification that the appropriate personnel have been trained. During the initial days of construction, the pipe manufacturer should provide an on-site observer, who should certify that correct installation procedures are being employed.

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10. **Field inspection.** It is recommended that GWA provide *full-time, open-trench inspection* of all sewer construction operations, including service laterals. GWA's construction inspectors should be trained in proper pipe installation procedures. The efforts of construction inspectors should be monitored by senior GWA staff. Senior staff should regularly (but not predictably) visit construction sites and should be present during all acceptance testing. GWA may also wish to consider a merit bonus program for inspectors whose projects pass performance tests with minimal corrections.
  
11. **Contractor payment procedures.** GWA should withhold 100 percent of payment for new construction until that construction passes the required performance testing. Testing should include both an inflow/infiltration test (air test or direct flow measurement) and a closed-circuit TV inspection. Contractors, who will want payment for partially completed work, will, of course, object to this practice. The resolution of this dilemma is to test the work in short sections, even as short as one manhole to the next, if necessary. Any sewer installed without an open-trench visual inspection should be considered to have failed testing regardless of the I/I rate. Any sewer that fails testing should be dug up and reinstalled. *No grouting to fix problems should be allowed.* Once contractors learn that poor workmanship will cost them money, quality will improve dramatically and rapidly.